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PART 1

OIL AND GAS

ENERGY RESEARCH IN DEVELOPING COUNTRIES

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ABSTRACT

Research must effectively assist policy decisions, however, it must be conducted by well-endowed, professional research institutions capable of providing independent advice. Research and development initiatives will create technologies that will transform indigenous energy resources to sustain the social and economic developments particularly in the rural areas in developing countries. The availability of reliable and sustainable energy resources, such as solar and wind energies, needs to be managed in a cost effective manner so as to reduce or remove a country's reliance on imported energy resources. The applications should be part of an integrated scheme covering a geographical area and aimed at providing better conditions of life. This requires a system of interactions carefully arrayed in space and time. Rural peoples must be both the principal actors and favoured beneficiaries of the process of integrating renewable energies. In practice, this involves the carrying out of diversified and coordinated activities which ultimately are in harmony with regional and national energy plans.

1. REASONS FOR RENEWABLE ENERGY DEVELOPMENT

Obstacles to development in developing countries rests with an adequate supply and distribution of food and energy (1). With respect to energy, particularly in the rural areas, from 75 to 90 percent of the traditional energy is in the form of wood, charcoal and vegetables wastes. Amongst other end uses, these sources of energy are primarily used for cooking meals, heating water and for lighting. If we are to develop energy systems which correspond to these basic needs we must identify the three basic types of energy, that is, thermal energy, mechanical energy and electrical energy. Equally important we must define the availability of energy, their characteristics, research and development and marketing.

2. PREREQUISITES OF RESEARCH

There is a consensus that the major issues and prerequisites in energy research in order to solve identifiable and prioritized developmental problems should examine the following:

i) Research that enables a review and evaluation of the action impacts and future implications of the oil crises, drought, and disertification on the sustainability and security of future renewable sources of energy.

ii) Research that provides a comprehensive dynamic analysis of energy production and use as well as baseline information for evaluation of alternative energy policies developed within the national energy goals and objectives.

iii) Research that leads to a comprehensive understanding of the socio-economic impact of the rural and urban sectors of the population.

iv) Research that leads to a practical field evaluation of the technical, economic and social acceptance of viable applications of renewable energy.

v) Research that aims to demonstrate, monitor and motivate acceptance and demand of efficient, cost-effective applications of renewable sources of energy.

vi) Research that explores the prospects of indigenous sources of energy which will provide a base for a sustainable growth of locally owned and operated small scale industries utilizing local technical available manpower.

To accelerate the practical applications of renewable energies it is vital that the renewable energy industries be fully equipped and be supported by a strong infrastructure and by skilled manpower. It goes without saying, that renewable energy must be integrated in the energy planning stages. In the evolution of a national energy policy some of the various elements which should be addressed are as follows:

a) Data Aquisition

The inadequacy of reliable data on solar and wind energies is a major obstacle to their development. This requires not only equipment for measuring the relevant input data but also the processing of the data issued in the selection of appropriate sites (2).

b) Standardization

Many entrepreneurs have presented unique designs suitable to meet the needs and desires of regions within a country. The standardization of data collection, processing and presentation as well as the establishment of testing procedures should be reviewed in each country with the expressed objective of producing a quality product which can compete with imported products.

All agree on the importance of (1) developing regional manufacturing within a country or among countries, (2) standards and specifications in order to facilitate an exchange of systems and/or system components and, (3) the insurance of a high quality product which is directly related to the defined needs of rural and urban communities.

c) Manufacturing

Special attention should be given to the development of manufacturing of biomass, solar and wind system components. Activities should focus on the assessment of relevent industries in a region and the corresponding investigation of availability of local resources and technological capabilities and capacities.

d) Technical Expertise

The lack of technical expertise hampers the wide-spread use of renewable energy technologies. Experience has already shown that it is imperative to have trained, experienced manpower for the installation, operation, repair and maintenance of these systems. To achieve this objective existing regional, or national training centres should be established. If on the other hand, a centre exists the government and international donor agencies should provide the infrastructure, finance and long-term job security for upgrading the facility consistent with the national energy policy.

e) Social Acceptance

Social acceptance is the key to the promotion of wide-spread utilization of renewable energy technologies. Governments should include within their national energy program direct input from rural and urban communities and a comprehensive promotional program to elevate the awareness of the socio-economic benefits of renewable energies. The users should be involved in the preliminary design and testing phases and in the operation, maintenance, and management of prototype and full-scale renewable energy systems.

f) Regional Cooperation

Close regional cooperation will benefit the users in areas where the shortage of capital and manpower results in delaying the implementation of national energy plans.

g) Incentives

A national policy for providing financial incentives should be adopted so as to minimize the capital cost. In rural and remote communities the utilization of renewable energies not only results in direct economic spinoffs but also adds to the quality of life. In these areas per capita income is often very low and it is the responsibility of national governments to provide substantial financial incentives.

h) Demand

Demand for renewable energy technologies stems, from among other factors, the need to improve apon the quality of life and small-scale industrialization. To this end, the direct involvement of the users is a key ingredient in the development of technically, economically viable yet socially acceptable systems. National and local governments should accept the task of promoting the use and benefits of renewable energy systems as an integral part of its energy activities. Integrating renewable energies into the global rural development programs in the agricultural, forestry and industrial sectors will enhance the growth and development of small-scale industries in the rural and remote areas.

3. RESEARCH - SIMPLE VERSUS SOPHISTICATED

A group of prominant energy experts from around the world under the direction of the International Development Research Centre analyzed the directions and issues of energy research in developing countries (3). Their report, an exhaustive non-biased analysis, contains several conclusions, and in particular, they concluded:

> "International funding agencies play a neutral to negative role in building research capacity in developing countries. Large-scale, site-specific research required for investment projects is funded by large investment funding agencies, whereas small-scale research, generally unrelated to production or commercialization, is funded by small funding agencies. They are not responsible for the lack of connection between policy, production, and use on the one hand and research on the other that is characteristic of developing countries: that disconnection arises from the dominance of multinational corporations in the production of capital-intensive energy equipment, the weakness of domestic firms in developing countries, and the passive energy policies of developing-country governments. However, international funding agencies also reinforce this disarticulation, and do little to remedy

the weaknesses of research institutions in developing countries."

Their conclusion is not at all unexpected. One of the important goals of a developing country with respect to industrialization is to import up-to-date foreign technologies and absord and diffuse them in order to strengthen the nation's technological capabilities. However, the other industrial goal of developing nations is to manufacture products using imported technologies and sell them in the international markets in order to earn foreign currency.

These goals may conflict with one another. To learn, absord and diffuse imported technologies a developing country should commence with simple technologies which are easier to learn. Yet, to produce products that will be competitive in the international markets the prerequisites of product quality (precision, standardization and consistent manufacturing processes) demand importation of techniques which are in general more sophisticated and utilize specialized, automated, numerical control mechanisms. These tend to be much harder to learn than simple technologies. Thus, the importation of sophisticated technologies in order to compete internationally could frustrate the process of learning, absorbing and diffusing the technologies.

A national energy policy should therefore choose a course of action which is between these two extremes: one is to emphasize being competitive in the international markets in the short term and the other is to build technological capabilities and capacities in the long term.

4. PRINCIPLES OF INTEGRATED RURAL DEVELOPMENT

Rural development is a system of inter-actions of numerous activities which when aimed at achieving the objectives of productivity, growth and improvement of the quality of life must be carefully scheduled over time. If rural development involves self-sustained development then the targeted rural population must be both the main actors and favoured beneficiaries of the development process in the execution of diversified and coordinated activities.

Experience has shown that successful integrated rural development (4) encompasses the following five basic principles:

a) simple, medium-term intervention; an initially limited scale at the outset

b) constant interaction between planning, execution and evaluation

c) dynamic analysis and in-depth understanding of the milieu

d) steadily increasing participation on the part of the target groups in decision making, in execution and in evaluation

e) diversification and strengthening of the support brought to local institutional capacity, both public and private

These characteristics no longer stem from a rigid top down planning "Blueprint Approach" but rather from a process that allows for the continuous reorientation of the project based on observed reactions. Through this mechanism, a project plan is transformed into a basic attitude characterized by strategic thinking which is continually generating action - a systems approach.

5. RESEARCH AND DEVELOPMENT

Research can assist national energy policies provided it is carried out by well-endowned, professional research institutions who provide independent advice to government and industry (5). Governments should assist in the development of regional and/or national research centres and provide incentives to stimulate innovation. To date, the extent and effectiveness of research and development leaves room for improvement.

Research is well understood in developing countries and it could be argued that there is too much of it and too little development.

Consider as an example, the reported analysis of 365 research projects in new and renewable energy in Latin America (4). Seven percent of the projects were directed to commercialization and twenty-eight percent were projects that may eventually have commercial potential. The balance, 65% of the projects, were in areas where it was too early to commercialize the results of the research. In developing countries public funds are more liberally available to research institutes that are not attached to producers and many of these research institutes are state owned.

Development is not simply a function of funding but requires special managerial skills. Emphasis needs to shift from basic research and development to research and development which will result in commercialization and dissemination of the socially acceptable products (6).

It is this author's opinion that research must depend on informed user capability, the continuous accumulation of knowledge, clear direction for research and goal-oriented funding. The informed user judges the problems, the quality of research and diffuses the results. The user must be trained to do and judge the research and from time-to-time update their knowledge. Knowledge takes time to accumulate and requires facilities and libraries to be used by the researcher in the system of learning and problem-solving. Researchers need to plan their career so as to increase their knowledge and versatility. To facilitate these essential requirements goal-oriented funding will require long-term investment in areas of importance to research users and the exploitation of the importance through projects leading to commercialization which will be of benefit to the needs of both rural and urban consumers.

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HIGH-TONNAGE CANE FOR MULTIPLE USES

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ABSTRACT

In many tropical countries such as Puerto Rico, domestic energy supplies must be developed to reduce dependance on imported fossil fuels. Sugar cane, generally thought of a source of sucrose, is perhaps the most promising single biomass energy resource available to the Caribbean. For over a decade, significant research programs in Puerto Rico have focussed on unlocking the enormous potential of sugar cane as an energy crop. This paper presents an overview of recent studies of high tonnage cane conducted at the University of Puerto Rico and presents data illustrating the technical and economic feasibility of utilizing this valuable renewable resource as a source of both food and fuel.

1. INTRODUCTION

The island of Puerto Rico depends almost exclusively on imported oil for its energy needs. In 1987 it imported millions of barrels of oil at a cost of approximately $360 million. The total electric power installed capacity of 4,200 MW supplies its 3.3 million inhabitants. If the island is to become more energy self-sufficient, it must substitute oil as quickly as possible, preferably with renewable energy resources. Given its tropical environment, it is logical to consider solar energy alternatives. Of the solar alternatives available, biomass, specifically highly productive plant crops, offers the best short-term potential. One of the finest potential energy crops and one with which Puerto Rico has had long experience is cane. During the past

decade, University of Puerto Rico research and development programs have demonstrated the enormous potential of multiple-use cane production technologies.

2. DEVELOPMENT OF THE ENERGY CANE CONCEPT

While sugar cane has traditionally been grown in Puerto Rico and throughout the Caribbean as a source of sucrose, it must now be reevaluated as an energy crop [2]. Due to rising production costs and falling market prices for sugar, sugar cane offers little economic potential as a food crop. In most countries, the sugar needed to satisfy domestic demand can be easily produced on a relatively small land area. As an export crop, the market potential for sugar and molasses is limited by reduced sugar consumption resulting from competition from high fructose corn syrups [3] and other sweeteners, low world market prices and excess production. However, as a renewable energy crop to replace imported fossil fuels, sugar cane's largely unexploited economic potential remains great [4].

The energy cane concept developed in Puerto Rico is based on the management of sugar cane not for maximum sucrose yield, but for maximum dry matter production (total fermentable sugars and combustible solids). The production of energy cane rather than conventional sugar cane involves important changes in agronomic practices to emphasize growth and tonnage rather than the sugar content of the cane. Under the leadership of Dr. Alex G. Alexander, the Biomass Division of the Center for Energy and Environment Research (University of Puerto Rico) has conducted research on multiple-use cane in Puerto Rico since 1977, obtaining average cane yields three times greater than those obtained by the island's sugar industry. These dramatic results have been realized through changes in key management practices such as the selection of high-tonnage varieties, improved land preparation, optimal fertilizer application, improved irrigation and harvesting techniques and the inclusion of cane tops and leaf "trash" in the final yield calculations.

Energy cane varieties have been developed through a process of careful selection and breeding. Sugar cane varieties selected for energy production must be vigorous growers with high rates of tillering and optimal production of dry matter, fiber and total fermentable solids, not necessarily those with the highest sucrose yield. In Puerto Rico, the "first generation" of energy cane used for cane biomass research included three high-yielding commercial sugar cane varieties: PR 980, NCo 310 and PR 64-1971. Average yields for these "first generation" exceeded 180 tonnes of millable cane/ha/yr in both plant crops and 1st and 2nd ratoon crops [2].

The "second generation" biomass varieties (US 67-22-2

and B-70-701) were selected for high biomass (fiber and fermentable solids) rather than sucrose yields. Total green matter yields for an 18-month crop averaged 369 t/ha (for US 67-22-2) and 304 t/ha (for B-70-701).

The "third generation" biomass varieties are being developed in a limited hybridization program begun in 1973 [7]. Highest production to date, obtained from progeny 79-1-10, amounted to 212 t/ha/yr (green weight) with 21.6% fiber compared to 14% fiber for US 67-22-2. Breeding work in Louisiana has produced progeny L 79-1002 with 25.5% fiber and 216 t/ha/yr green matter [6].

At present, average cane yields in most sugar-producing countries of the world are approximately 58 t/ha/yr (millable stalk, green weight), or a total of 73 t/ha/yr if cane tops, leaves and leaf "trash" are included. On a dry weight basis, this total is equivalent to 18 t/ha for a 12-month crop. Production of 135 t/ha/yr green cane is not uncommon when adequate water and fertilizer is available. In contrast, energy cane grown in Puerto Rico in a 12-month commercial trial [7] produced as much as 280 tonnes per hectare green whole cane (or 112 t/ha total dry matter) using energy cane variety US 67-22-2.

When evaluating cane as an energy source, it is important to consider the composition and potential energy yield of the crop components. Typically, a tonne of whole, green, mature, unburnt cane in the field consists of 600 kg of millable cane (100 kg dry matter) and 400 kg of tops and leaves, or "field trash" (200 kg dry matter) [8]. In normal cane milling and sugar processing operations, approximately 75% of the residual organic material remaining after grinding the millable cane ("bagasse") is immediately used for boiler fuel to produce process steam and steam to generate the power required by the mill itself. Thus, for each tonne of cane in the field, approximately 225 kg dry matter is potentially available for use as a boiler fuel to generate electricity for use outside of the sugar mill complex, 200 kg from the generally unused "field trash" and 25 kg from excess bagasse. This 225 kg of dry material has an energy value of approximately 1.01 million kcal, equivalent to the energy value of 0.68 barrels of fuel oil [8]. In Puerto Rico, for example, with its current annual harvest of 1.3 million tonnes of cane on 22,500 ha, excess bagasse and "field trash" represent an annual potential fossil fuel replacement of approximately 1.5 million barrels of fuel oil [9], a significant proportion of the island's current imports.

It is common practice in many sugar cane growing areas of the world to burn the cane fields immediately prior to harvesting. While this practice facilitates recovery of millable stalks, it is a wasteful practice from the point of view of maximizing energy yields as it effectively precludes recovery of energy-rich leaves and "field trash".

In contrast, energy cane arriving at the cane processing plant consists of the whole, unburnt cane stalk, including both millable cane and tops, and associated leaf material. The utilizable, combustible organic matter, or bagasse, consists mainly of fiber from the stalk, tops, and leaf trash that remain following grinding at the cane mill. A ton of bagasse dried to a moisture content of 6% has a caloric value of 17.4 x 10^9 J with an electrical equivalent of 4,348 KWH.

The fermentable juice extracted from the cane is usually converted into sugar and molasses. The molasses is used in cattle feed or fermented into alcohol with a yield of 0.37 liters of ethanol per liter of molasses. Alternatively, cane juice can be fermented directly without producing sugar or molasses to obtain 65 liters of ethanol per ton of cane.

3. THE MULTIPLE-USE CANE COMMERCIAL DEMONSTRATION PROJECT

A two-year Biomass Demonstration Project was conducted between 1986 and 1988 on 105 hectares of farmland at Santa Isabel, Puerto Rico to evaluate on a commercial scale the potential biomass and sugar product yields and economic costs (from land preparation through harvest) for producing several multiple-use varieties using improved gravity and drip irrigation technologies. The varieties grown were PR 66-2281, PR 67-1355, PR 67-1070 and US 67-22-2. A number of important results and conclusions applicable to the development of cane energy systems elsewhere in the world were drawn from this Project [10], and are discussed below.

Growing high tonnage cane using good irrigation and sound agronomic practices presented no significant problems at Santa Isabel, located on the south coastal plains of Puerto Rico. Average monthly production rates in this study ranged from 17 to 23 t/ha of millable stalk and 20 to 27 t/ha of whole cane for both the plant crop and first ratoons (see Table 1).

While total biomass production rates were comparable among the cane varieties tested, the composition of the cane crop did vary with variety. For example, mature stalk comprises 85%, 74%, and 68% of the total biomass produced for a 12-month crop of PR 66-2281, PR 67-1355 and PR67-1070, respectively [11]. These varietal differences in plant composition are important when considering use of the plant crop as a biofuel. A high leaf:stem ratio may appear to be desirable as the production of total fiber per hectare may be maximized. However, when considering the harvesting, materials handling and processing, a high stem:leaf ratio is definitely preferable as the total product may be handled more efficiently by conventional harvesting and processing systems [11].

Table 1. Average standing crop and composition of multiple-use cane varieties planted at Santa Isabel, Puerto Rico, 1986-1988. Adapted from [10].

Variety		Irrigation System	Standing Crop (tonnes/ha) Millable Stalks	Tops & Leaves	Detached Leaves	Total	Total per Month
PR66-2281	PC	GB	222	38	11	271	22.6
	PC	GF	225	38	2	265	22.1
	PC	Dr	239	39	4	282	23.5
	Ra	Dr	154	34	2	190	21.1
PR67-1355	PC	GF	206	37	5	248	20.7
	PC	Dr	270	51	5	326	27.1
	Ra	Dr	170	37	3	210	23.3
PR67-1070	PC	Dr	222	42	4	268	22.3
	Ra	Dr	158	39	2	199	22.2
US67-22-2	PC	Dr	214	56	2	272	22.7

Notes: Variety - PC = Plant Crop (at 12 months); Ra = Ratoon (at 9 months)
Irrigation System - GB = Gravity, border; GF = Gravity, furrow;
Dr = Drip irrigation

In this Project, approximately 77% of the farm area utilized drip irrigation systems. The remaining area utilized graded furrow (19%) and graded border (4%) irrigation. Little difference was noted in cane production between drip and gravity irrigated areas. In addition, total irrigation water input was approximately the same for both irrigation systems; plant crops needed 137 to 145 cm of water/yr and ratoon crops about 109 cm/yr [10]. A definite linear relationship was found between the amount of water applied to the crop and the the amount of plant biomass and sugar produced. Approximately 59 to 72 tonnes of water are needed to produce one tonne of whole, green cane; 70 to 105 tonnes are used to produce one tonne of mature stalk; and 200 to 350 tonnes of water are needed to produce one tonne of cane dry matter.

Harvest systems used in the Santa Isabel Project included both manual harvests and mechanical (Claas combine chopper-loader) harvesters. Harvesting efficiency was much greater for manual than for mechanical systems. The proportion of the standing crop of millable cane lost by these systems were approximately 9% and 30% for the manual and mechanical systems, respectively. Currently available combine harvesters are inadequate to efficiently harvest high tonnage cane, particularly in fields utilizing drip irrigation systems. Manual harvest appears to be the harvest method of choice until appropriate mechanical harvesting systems are designed to handle high tonnage cane [10]. In the case of manual harvests, a separate collection of tops and leaves ("field trash") using currently available forage harvesting machinery is recommended [9].

4. THE AGUIRRE BIOMASS ENERGY FEASIBILITY STUDY

The Center for Energy and Environment Research is currently completing a study assessing the technical and economic feasibility of developing a complete biomass energy production and utilization system based on multiple-use cane produced in the vicinity of the Aguirre sugar mill in Puerto Rico. This study, sponsored by the Puerto Rico Office of Energy, is closely linked to the Commercial Demonstration Project discussed above.

As presently envisioned, approximately 5,000 hectares of cane farmland currently supplying the traditionally-managed sugar mill at Aguirre will be managed for high-tonnage cane production using the improved techniques tested on a commercial scale in the Demonstration Project. The cane would be delivered to the mill and processed for sugar and molasses extraction. Given expected crop yields, the bagasse produced at the mill along with the additional "field trash" collected at harvest would be sufficient to fuel a high-pressure boiler and turbogenerator with a total generating capacity of approximately 25 MW on a year-round basis.

Approximately 20% of the total generating capacity would be used to operate the mill complex; the remaining 80% would be sold through Puerto Rico´s Electric Power Authority.

Current estimates indicate that the Project will indeed be economically viable. The combination of increased sugar product yields and the excess electric power produced using cane biomass are expected to offset within a few years the initial investments required to improve productivity at the farm level and to build and operate the new boiler/turbogenerator unit at the Aguirre mill. In addition to substituting locally-produced biomass fuels for imported oil, if implemented, this project will help to stabilize an otherwise faltering sugar industry in Puerto Rico through improvements in agricultural production and processing methods and efficient use of previously underutilized biofuels.

5. CONCLUSIONS

Sugar cane is perhaps the most promising single biomass energy resource available to many parts of the world, particulary in tropical regions, where an estimated 600 million tonnes are harvested annually. Through careful genetic selection, improvements in agricultural production techniques and adoption of efficient, innovative harvest and conversion technologies, this crop has great potential as a biofuel. Research and development programs in Puerto Rico have resulted in dramatic yield improvements, and have demonstrated the technical and economic feasibility of using this valuable renewable resource as a source of both food and fuel.

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POWER PLANT LOAD MANAGEMENT - AN EFFECTIVE TOOL FOR ENERGY CONSERVATION

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ABSTRACT:

Variable load on a power plant is a feature which is governed by the requiremants of the consumers. The variation in load is a major source of power loss. Proper efforts, if put in minimising the variation of load, can lead to a lot of saving in terms of fuel or money.

A case study concerning the Tripoli regional network is presented in the paper to support the idea.

1. INTRODUCTION:

Due to the fact that electrical energy can not be stored economically the momentary demand and the corresponding generating and distributing capacity has to be matched to one another. The variation in demand is dictated by the rhythm of the life of the population served or production processes in industry. Climatic conditions have a decisive influence. Such parameters as temperature, light-intensity, atmospheric humidity, wind-speed etc. contribute towards determining the shape of load curve.

Variation of the load on a power system with the hours of the day poses conditions for the plants to be met successfully all the time to satisfy the customer needs. Customer requires electrical energy at a certain quality and quantity at the agreed cost.

The load in a utility system is usually a mixture of several types e.g. industrial, agricultural, residential, municipal etc. Each type has its own distinguished pattern of daily and seasonal variation and the total system load curve is formed from all of them.

The presence of peak and off-peak loads on a daily load curve present constraints on the utility in trying to meet these variable requirements by putting the generator units on and off frequently. This results in an uneconomic running of these units which means costlier energy.

2. LOAD MANAGEMENT:

To reduce the number of peak and off peak loads and the difference between these values, i.e. to have a more flat load curve, some kind of management (control) of the customer load and the utility program is needed. Several ways have been tried to achieve this goal with different results for different utilities and customer conditions.

Methods of load management can generally be classified into direct and indirect methods. In the former type, the utility controls directly certain types of its customer loads e.g. water heaters, air conditioners etc. by switching them on and off according to the load on the system and hours of the day through certain signals sent to the load via a certain communication link connecting the supplier to the receiver. In the latter type, the shift of loads is achieved through inducing the customers to change their patterns of loads i.e. the time of their maximum and minimum loads in a way to help flattening the total load curve of the utility. This can be done through mutual understanding and agreement or by implementing a tariff policy directed to serve this goal by charging higher rate per KWh for loads at utility peak hours and lower at off peak ones.

Whether to apply direct or indirect method of load management, depends on the utility as well as the customer's specific conditions. Load management offers considerable savings in the use of electrical energy by creating awareness among the users regarding the cost involved and the actual value of the energy. It helps in reducing the generating cost through more economical use of the generating facilities.

Both direct and indirect methods have been applied in several utilities in different countries with varying degree of successful results in getting the desired shift in the customer load with accompanied reduction in electrical energy consumption levels.

It is to be noted that the expenditure involved particularly in direct load management installation of system equipment and their operation and maintenance should be kept low enough to justify the introduction of load management program. The social impact of load management is an important factor for due consideration when assessing the program to guarantee adequate social acceptability to the possible inconvenience the program application may introduce.

3. TRIPOLI LOAD:

With regard to the generation and distribution of electrical energy, the Jamahiriya is divided into four regions of Tripoli, Benghazi, Sebha and Sarir. The average daily load curve of a typical day of the first Feb. 1988 is given in Fig.1, giving the qualitative and quantitative idea of loads in the regions. It is clear from the figure that the Tripoli load is highest of all and the variation throughout the day is also remarkable. Therefore, the present study is confined to the Tripoli region only.

The nature of the Tripoli load can be studied through Figs 2-4. Fig. 2 depicts the yearly load curves for two years of 1986 and 1987. It is to be concluded that load during the months of January-March and during July and August is more while during November it is the minimum of the year.

Typical winter and summer season daily average load curves for representative days of years 1982 to 1988 are shown in Figs. 3 and 4 respectively. For the years 1985 to 1988, in winter, two peaks are occuring around 10.00 A.M and 7.00 P.M while the minimum load is during 2-5 am (Fig.3). A closer look at the Fig. 4 discloses that for summer season, peak load was seen around 9.00 pm while the minimum load during 3-5 am

4. LOAD MANAGEMENT FOR TRIPOLI AREA

The Tripoli load can broadly be divided into four types of residential (35%), agricultural (30%), industrial (20%) and commercial and municipal (15%).

The base load is met by steam turbines and the peak load is taken care of by Gas Turbines. Out of the total installed capacity of 1603 MW, steam turbines share 1105 MW while the rest 498 MWs are shared by Gas Turbines. As the installed capacity is more than the maximum possible demand, various load management techniques are not popular, but due to the rising standard of living and due to the implementation of the National socio-economic development plans, load is constantly rising and it may not be possible to pace the increase of load with the increase of installed capacity. Therefore, it is highly desirable that load management techniques are implemented in the Jamahiriya.

5. RECOMMENDATIONS.

Based on the present state of affairs and the local prevailing conditions, the following recommendations are made:

1) Data collection, documentation and analysis have to be enhanced for effective load management. The quantitative idea of each type of load and its duration for each sub-station will help power engineers to control the amount of electricity generated and it will result in a lot of savings. Digital computers can be used for this purpose.

2) In a typical summer night the load is of the order of 400 MW during off-peak hours while the same may rise to a value of 900 MW during certain hours of the same day. A tariff policy encouraging off-peak energy consumption may be planned and implemented.

3) Load staggering may be helpful in providing cheaper electricity to consumers. Irrigation is more during summer season (i.e. May-Sept.) and the farmers may be provided power during night hours. Industries may observe different days as their weakly off days. Two shift or general shift units may be asked to have round the clock production program. This will reduce the load during peak periods.

4) More use of non-conventional sources of energy is the need of the day. Though solar, wind, ocean, thermal and wave energy sources are immense in the Jamahiriya, but only solar energy can help in fulfilling the power need of the country. Solar radiation in watts per m^2 is of the order of 270 for Libya. Solar water heating and solar cooking should immediately be made popular among general public. At a later stage, solar refrigeration has to be introduced. These equipment may be provided at subsidised rates to common people and technical assistance may be available free of cost.

5) There is little awareness of need for energy conservation in the country at present, presumably, because the home demand of energy is small in relation to the exports of energy. However, the home energy demand is increasing and it is essential to consider ways of conserving energy. Electrical distribution losses are reported to be of the order of 30 per cent which is a very high figure. By having better design of buildings, energy needed for illumination can be saved to a large extent. All-round efforts are to be made in educating the public in this regard. Posters, advertisements in news papers, and on T.V., exhibitions, etc. may prove to be helpful in this direction. Public awareness regarding energy crisis will lead very good results.

Generation and distribution losses are to be kept at minimum level. Technical staff responsible for these duties should be properly qualified and short term training programmes should be conducted to keep them abreast of the latest developments in the area.

6. CONCLUSION:

Load management, direct or indirect, can help in conserving energy through improving the system load curve. Local conditions of the utility and customer determine the proper method to be applied for achieving this goal.

The paper through the available information on the Tripoli Electrical System suggests preliminary steps leading to a suitable load management program. Further studies can be carried out to assess the totality of the problem.

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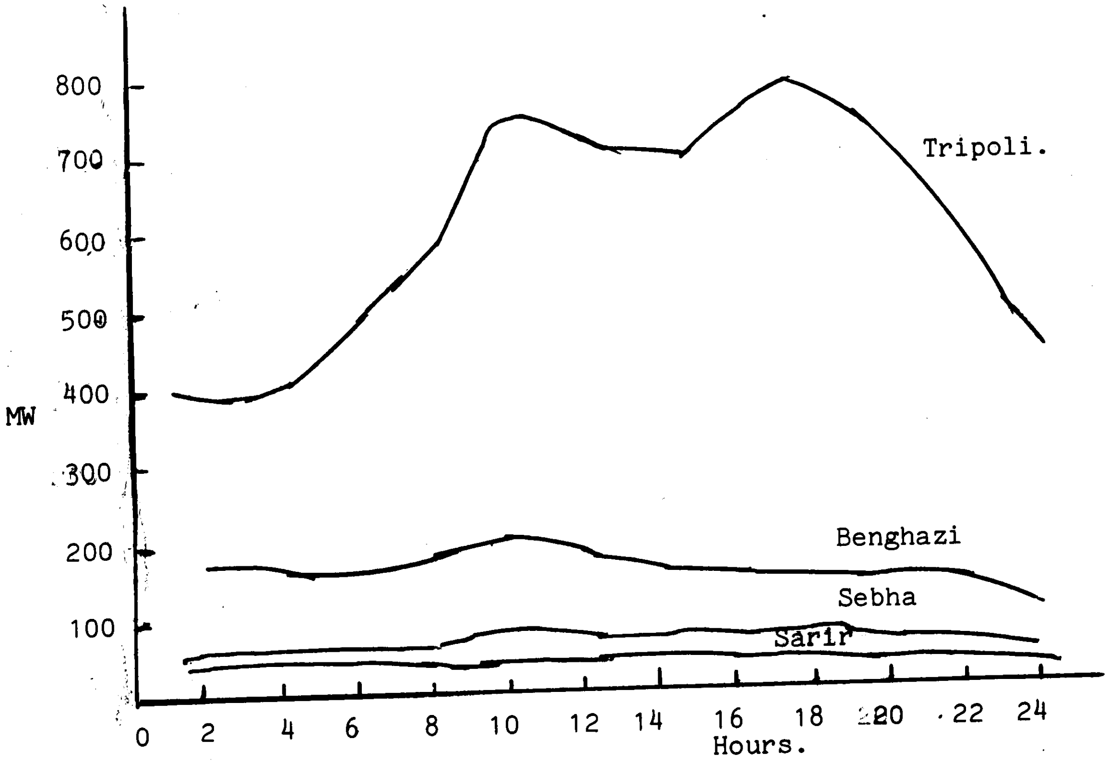

Fig. 1. Daily Load Curve.

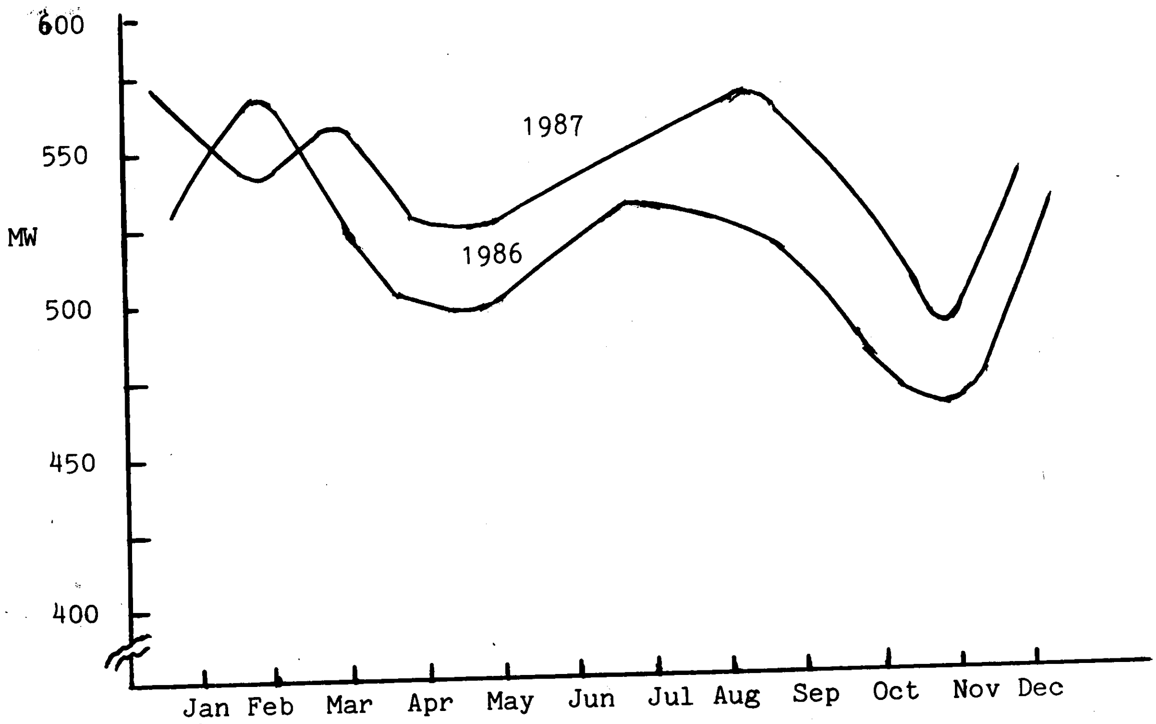

Fig. 2. Average Annual Load Curves.

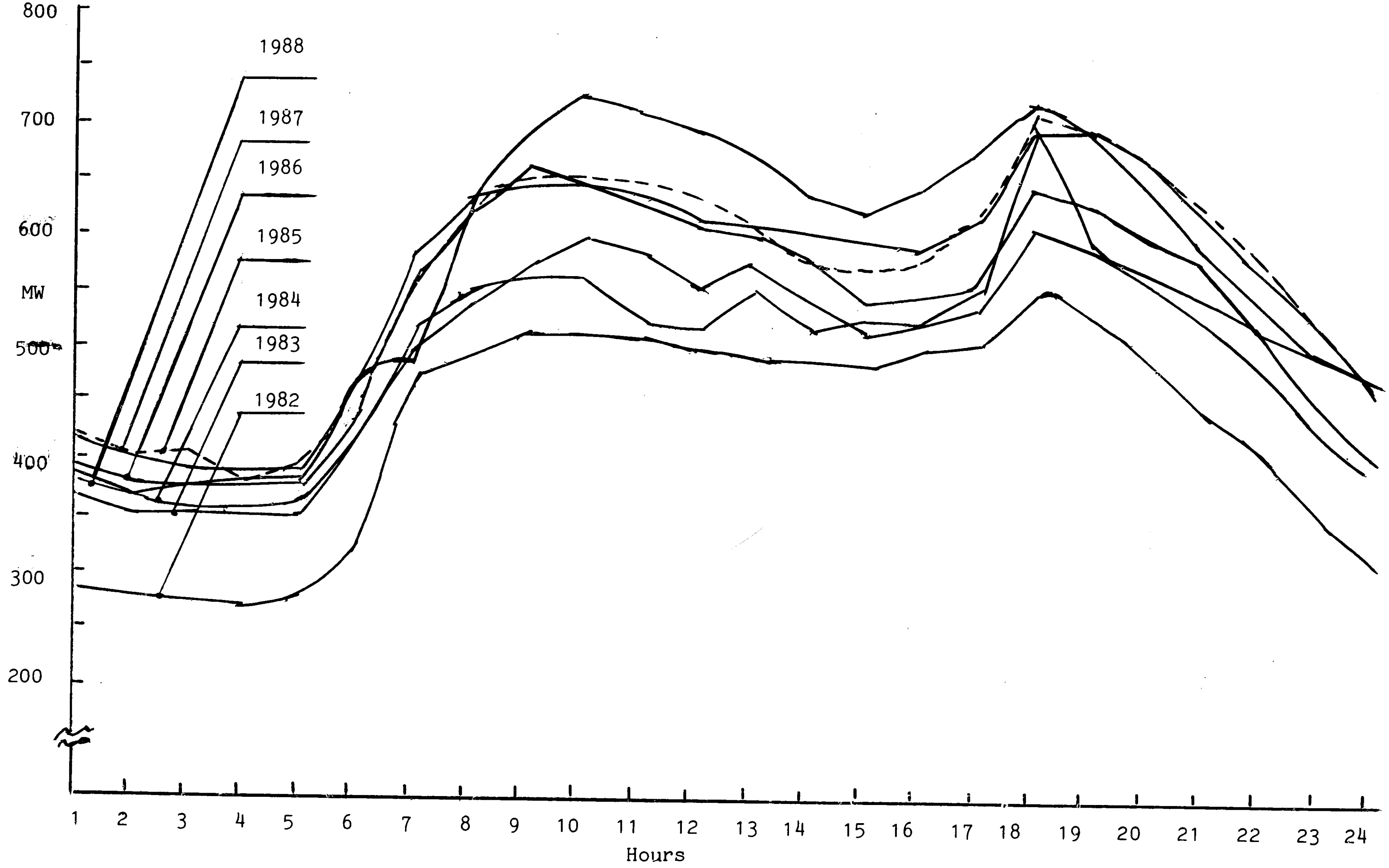

Fig. 3. Winter daily load curves.

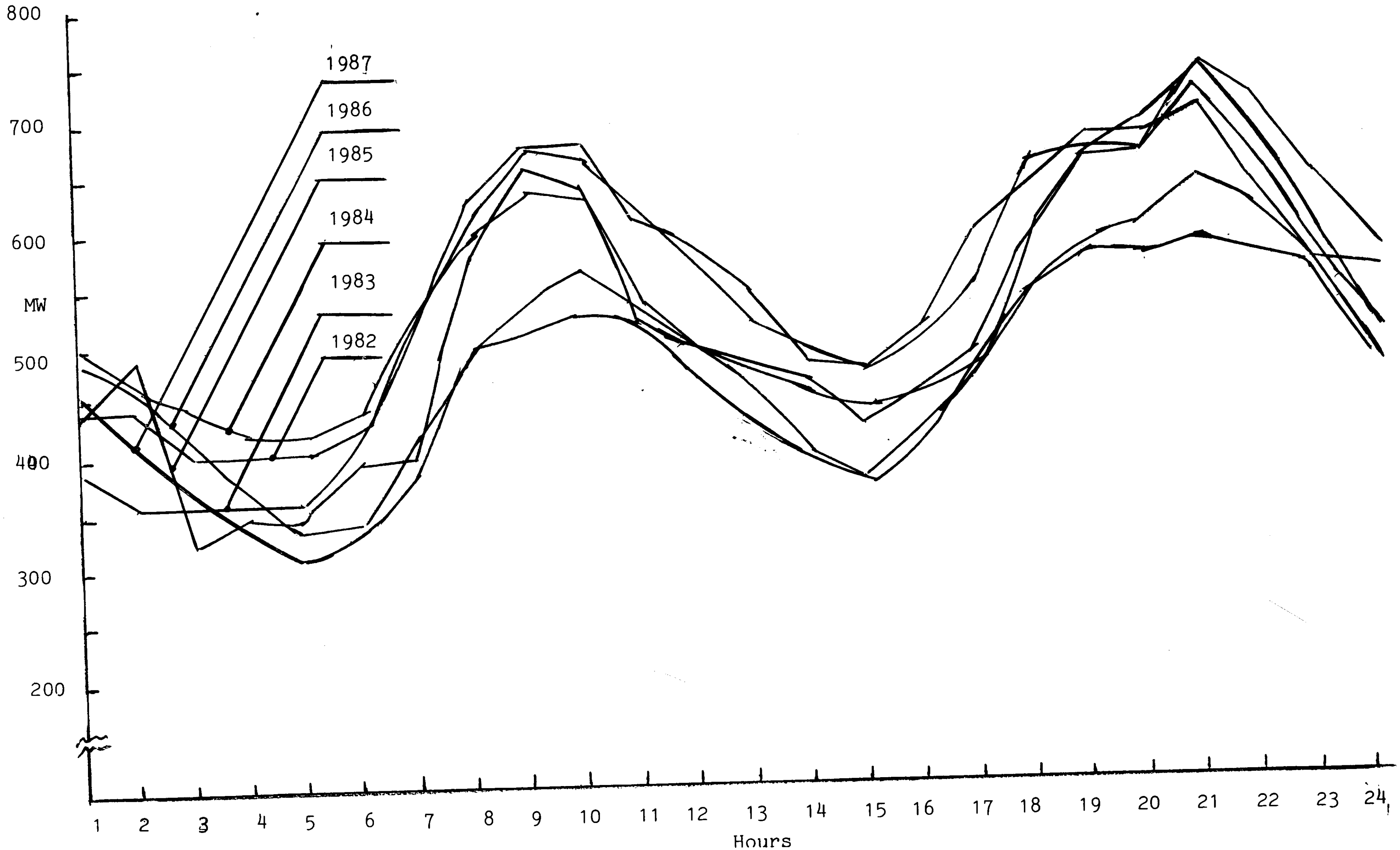

Fig. 4. Summer Daily Load Curves.

Conserving Energy Through Better Plant Design

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To carry out industrial processes using minimum energy consumption has become one of the challanging task of the designers and engineers today. During the last decade there has been a clear shift in emphasis from cost economic design to energy economic designs of plant and machinery. This paper reports a study conducted in Indian industries on the scope for energy conservation. It is shown that in mechanical and chemical and allied industries, quite a good amount of energy consumed can be saved by the efficient use of properly designed processes, equipment, and systems. Also given in the paper are the cost - benefit analysis of some of the energy saving proposals.

1. INTRODUCTION

The need to conserve energy in industry to-day is particularly important in view of the rising costs and, at least in the short to medium term, potential shortages because of depleting reserves of fossil fuels. Whether influenced by costs or by social responsibility the industry must initiate action to implement energy conservation programmes. Studies are being conducted to improve the industrial processes and plant machinery from the point of view of energy consumption. The energy manager, therefore, needs to have accurate and up-to-date information on energy saving techniques and equipment available. He ought to have a say in the selection of new machinery to be purchased. For the equipment already existing in the plant, he must concern himself with such questions: How efficiently is the energy used ? Can it be improved ? How ? What energy savings will result and how much will it cost ? In this paper an attempt is made to highlight various programmes which can be implemented to modify the machinery or equipment so as to effect savings in energy. The matter reported here is based on the results of a study conducted in ten Indian industries on the implementation of energy conservation programmes.

2. ENERGY SAVING PROGRAMMES

The programmes of energy saving can be grouped as under.
(i) Low cost activities, e.g., good house-keeping, use of temp. control systems, application of proper insulation, etc..
(ii) Use of energy recovery techniques
(iii) Use of energy efficient processes.

2.1 Low Cost Activities.

There are a number of activities which donot cost much but are quite effective in saving energy in a plant. One example of this is the use of thermal insulation for reducing heat loss. Some of the important activities which can be carried out in conjuction with commonly used equipment in mechanical and chemical engineering industries are considered here.

2.1.1 Thermal Insulation.

The most common form of thermal insulation used in industry is the fibrous material applied as lagging on pipes, boiler hotwell and condensate return lines, and fuel storage tanks. Presently, the application of thermal insulation is mostly on adhoc basis, applying as and when convenient. The selection of proper material for thermal insulation and its thickness are critical parameters [1]. There are a number of materials available, each one suited to a particular environment. The optimum thickness of thermal insulation is related to the trade-off between the cost of insulation and that of heat loss, Figure 1.

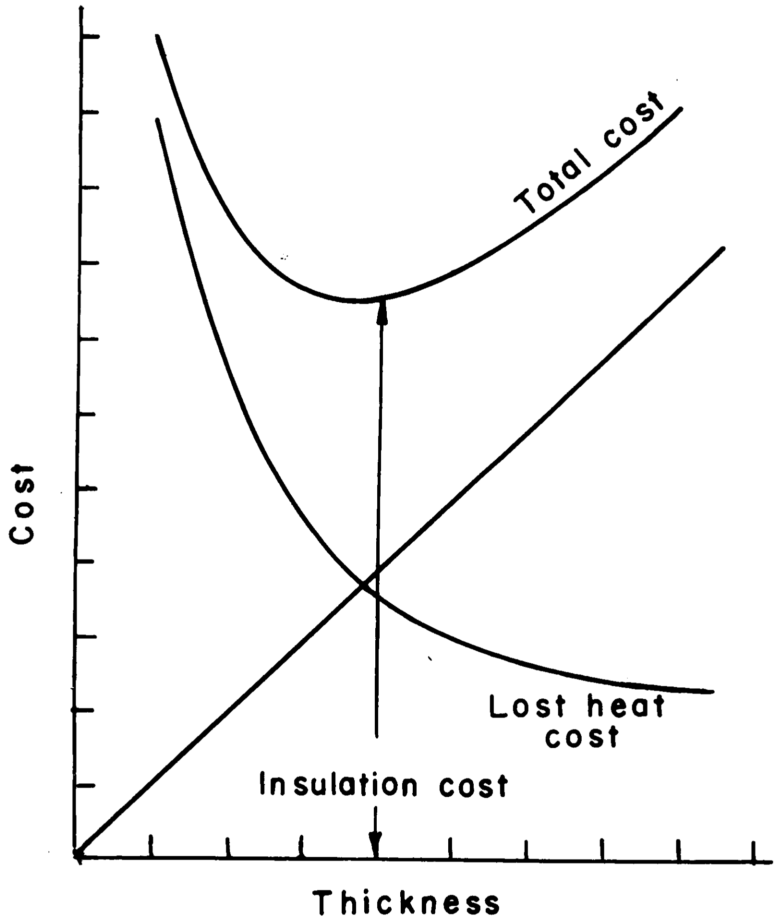

Figure 1

Thermal insulation of hot liquid surfaces is becoming quite important these days. One technique being effectively applied is based on the use of hollow polypropylene balls. These balls float on the surface of the liquids as 'blanket' to provide almost complete cover without the disadvantages of solid lids. The material is resistant to to most acids and other industrial fluids and can be used at temperatures considerably higher than the boiling point of many fluids. One or more layers of balls may be used depending on the extent of heat loss permitted. In one typical case, water was to be maintained at constant temperature of 90 deg C. Heat loss from the water was reduced by 75.5 percent with double layer of balls. Such a technique not only saves fuel but also keeps more uniform temperature (important to many process industries) and low level of evaporation.

2.1.2 Boilers. If a boiler system is producing steam or hot water, the use of adequate amount of insulation on at least all main lines is essential. Leaks should be repaired as soon as possible. The storage tanks may be used to conserve energy by receiving hot water during off-peak periods.

Efforts should be made to recover heat from boiler condensate and boiler flue gases as this has been found to save as much as 20 percent of boiler fuel input. Boiler blowdown is a source of heat and should be recovered in a blowdown heat exchanger. It is found to be economical particularly in instances when poor quality feed water necessitates frequent blowdown.

Maintenance of the boiler itself is also not less important. Cleaning of the shell and tube sides, and burner combustion efficiency affect fouling as well as heating rates. Humidification of the combustion air supplied to the boilercan help in preventing boiler fouling. During burner - off periods boiler flues can be isolated to take full advantage of the thermal storage capacity of the boiler. For this, use can be made of any of the several available devices.

2.1.3 Chimneys. Chimneys working on natural drought are most susceptible to growing contamination. It is important to regularly inspect the top of the chimney, becuse if tar, grit, or any other contaminants have deposited there, it can lose as much as 50 percent of its effective area, thereby seriously affecting the ability to maintain a sufficient drought.

A combination of induced and forced draught system should be preferred the forced draught fan may supply primary air for the combustion process and secondary air for the burning of volatile matter. Forced draught systems tend to operate with chimney base temperature about 40 percent below those of a good natural draught system, with a proportional reduction in flue heat loss. In a poor natural draught installation as much as 30 percent of the heat in the system may dissipate through the flue gases. If the chimney top is choked and the inside of the stack contaminated , heat losses can be 50 percent greater than when the natural draught system is properly maintained.

2.1.4 Combustion systems. A good amount of energy can be saved by raising the fuel consumption efficiency of boiler, furnaces and other heating plants which use coal, oil, or gaseous fuels. In general, combustion efficiency can be improved by using a better burner and/or by installing a control system which can adjust air-fuel ratios as necessary depending on load and ambient conditions. Performance is improved if the burner provides the required flame geometry and the flame is directed to where it will be used most effectively. In one case significant fuel savings resulted through the use of a specially designed burner. This burner was developed to meet the requirements of high heating rates in furnaces and it used the concept of very rapid recirculation of the heating medium within the furnace chamber, heat transfer to the load being accomplished by forced convection at all stages of the cycle.

In case of large furnaces automatic flow control systems which operate either hydraulically or electronically may be used. These control systems monitor combustion chemistry and adjust the flow for optimum efficiency. Further technical advice on the design of burners and combustion performance of different fuels is available from consulting agencies like Indian Institute of Petroleum.

2.1.5 Compressed Air Systems. Compressed air is used in a plant very freely often ignoring the fact that it is a comparatively expensive form of energy. The compressors consume electricity or in some cases oil or gas fuel, and the compressed air is too expensive to be used for applications which can be avoided, or for which cheaper methods are available. It is however possible to reduce the cost of compressed air systems by measures like plugging any leaks in the air lines, reducing the system pressure to the lowest acceptable for the application, etc..

2.1.6 Dryers. Dryers constitute important part of a large number of industrial processes. Drying is of several types but separation of any liquid from a solid is the one commonly used in industries. The separation can be carried out either mechanically, for instance by centrifugal processes, or thermally by direct or indirect heating. It is seen that potential for energy conservation is higher in thermal drying processes, and the following guidelines are useful in this regard.

1. Use natural drying process than hot air or steam method. An example application of this guideline is in timber seasoning.

2. Remove moisture from the product upto the extent just required. Over heating not only consumes additional energy, it may also be detrimental to product or to product quality as well as rate of output.

3. When dryers have to be used, care should be taken that the material has the least moisture content prior to drying. For this the material may be covered when stockpiled if in a damped atmosphere, or arrangement made so that some natural drying can take place. In some industries as much as

10 percent of the fuel needed in the dryer has been saved by only a 1 percent reduction in aggregate moisture content.

2.1.7 Furnaces. Furnaces are among the greatest users of energy in industry, and are prime candidate for the application of energy conservation techniques. In one industry furnaces used were having natural draught systems with a low heat transfer efficiency of around 65 percent. Use of forced draft fans and an air preheater raised the efficiency to as high as 89 % . In another case a 1 percent efficiency improvement in a furnace of 30 millions Watt firing capacity yielded a saving of Rs.4 lakhs per annum [2].

2.2 Energy Recovery. In some industries there may be certain items of plant which can usefully employ waste energy recovery equipment and thereby raise percent utilisation of energy. These equipment although require considerable investment, the returns on investment are usually high. It is recommended that before actually considering the use of any of these equipment a cost - benefit analysis be carried out under the existing conditions. If more than one alternative is being considered, the one which gives shorter pay-back period should generally be preferred.

2.2.1 Boilers. In case of boilers heat recovery can be accomplished by the use of

(i) Boiler air preheaters
(ii) Boiler condensate return
(iii) Recovery of boiler blowdown.

A boiler preheater recovers heat from the flue gases and preheats the combustion air. The quantity of heat recovered must be weighed against the capital cost of the preheater and the cost of equipment modifications that may be required to be carried out. Returning the boiler condensate to the boiler as boiler feed water may result in a saving of 10 to 20 percent of the amount of fuel used for steam making. To overcome the problems associated with intermittent blowdown of boilers when total 'dissolved solids'level is high and generation rates are low, it is recommended that continuous blow-down of the boiler be carried out if the average boiler requirement for blowdown exceeds 10g per sec because this has considerable potential for waste heat recovery. Further this system can also be fully automated without interfering with the boiler steam raising rate or pressure.

2.2.2 Combustion Burners. In order to improve the thermal efficiency of small size batch forge furnaces, which in some cases may be as low as 10 - 15 percent (because approximately 70 percent of the heat supplied gets lost up the flue), use may be made of a recuperative burner which incorporates the functions of burner, flue, and recuperative into a single unit. In this a counter-flow gas-to-gas heat exchanger surrounds a high velocity nozzle -mixing burner. The outlet for the spent furnace gases is located on the top of the burner enclosure.

Figure 2 shows one such burner developed by British Gas Corp. Applications where this type of burner has demonstrated its good efficiency and fuel economy include forge furnaces, reheating furnaces, intermittent kilns, soaking pits and heat treatment. Reference to some other types of efficient burners can be made in [3].

2.2.3 Dryers. It is recognized that control of dryer conditions minimizes the energy consumption considerably. Further decrease in energy cost can however be achieved through the use of heat recovery systems. There are several ways in which this can be accomplished.

A heat exchanger can be used to recover the heat from the air exhausted from a dryer before it is finally rejected to the atmosphere. Many designs of heat exchangers are available. Figure 3 shows a run-arund coil type of heat recovery system used on a continuous dryer. In this type, the coils in the inlet and exhaust ducts take the form of extended surface heat exchangers. The circulating fluid may either be water or some other high temperature organic heat transfer fluid. Use of this system permits savings of upto 50 percent in the amount of heat required by inlet burners. Another efficient design of dryer which is used for pulp, powders, pellets, or any granular material, and which employs heat from the exhaust gases is

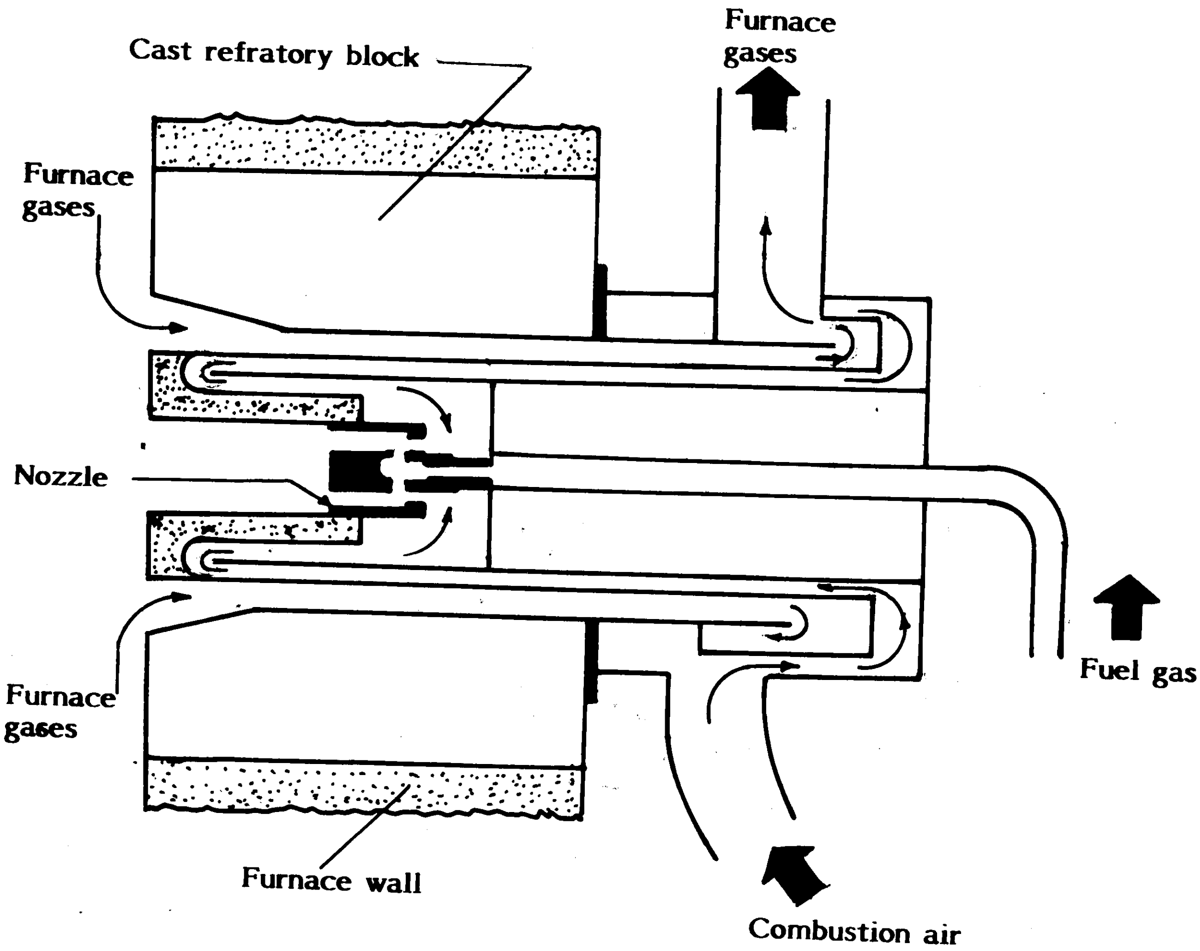

Figure 2

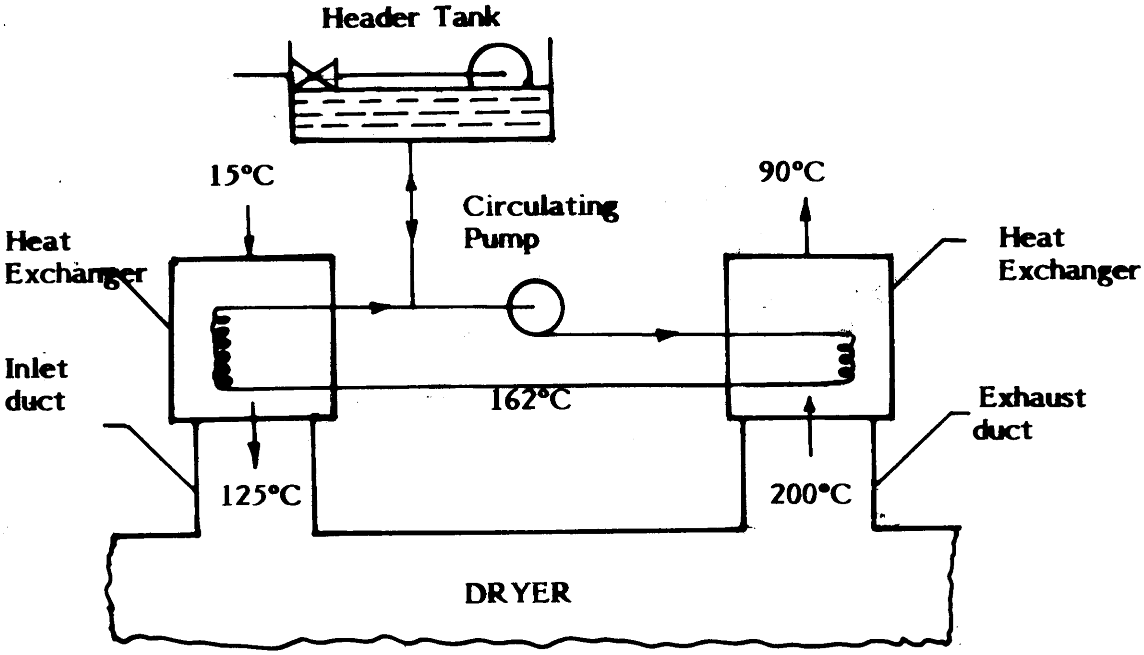

Figure 3

called the turbo-tray dryer. In this type of dryer, a series of superimposed annular shelves are mounted in a rotating frame. Wet material is fed to the top shelf wherefrom it is carried in a thin layer on the rotating trays. The speed of rotation is so adjusted that after each tray has completed cne revolution the material gets dried so that it can be removed.

Yet, another type of dryer used primarily for batch processing in which wet particles are suspended in a vertical airstream to be dried by forced convection is called fluidised bed dryer. The use of waste heat from the boiler flue makes this type of dryer economically quite attractive.

2.2.4 Furnaces. Different energy saving techniques have been tried with success on furnaces of different types used for different purposes (like melting, heat treatment, etc.). For example, in case of iron melting furnace Cupola, the use of divided blast system can reduce coke consumption by about 25 %. This is a simple system in which the air required to burn the coke is blown into the cupola through two (instead of a single) rows of tuyeres correctly spaced apart. The capital cost of installing this system is so low that payback period is only about two months in some cases.

2.3 Energy Efficient Processes. There are several industrial processes which were originally developed for specialized jobs and were hitherto being considered approperiate only for high technology industries. With improvement in technology, these processes can now be used in most other industries also for the purposes of heating, welding, and cutting with less energy consumption than other commonly used conventional processes.

The following gives a brief description of some of these processes.

2.3.1 Heating. Dielectric and microwave heating offers considerable amount of saving of time and energy when heating materials having poor thermal conductivity because with this technique heat is generated throughout the component body, independent of the thermal conductivity. To apply dielectric heating , material to be heated is put between two electrodes connected to a high frequency generator. The electrodes may be in contact with the material or šeparated to allow a conveyer to pass between them. In microwave heating, unlike dielectric heating, the very high frequency energy penetrates more deeply into the work material and also the means of application are more flexible. The superiority of microwave heating over dielectric heating was also noticed by Dunlop [4] during the development of a method of preheating conveyer belting prior to vulcanisation. Using microwave preheater, a reduction of curing time of one third was obtained.

2.3.2 Welding. In Electron Beam Welding, a focussed stream of fast moving electrons is used to generate the high energy for weld two metal pieces. By concentrating all the energy directly at the weld joint, and ensuring that the energy in the electrons is effectively converted into heat , the process is inherently an efficient user of energy. A number of other features of the process which ensure minimum material waste also indirectly contribute towards energy conservation. Due to relatively low but highly concentrated heat input a weld with high depth/width ratio and uniformly distributed stress is obtained. More advantages and details of the equipment for this process can be seen in reference [5].

Laser welding is somewhat similar to electron beam welding in so far as operating advantages and metallurgical benefits are concerned. In most industrial applications laser welding is preferred because no vacuum chamber is needed, and the unit is simple with a wide range of weld powers. The same optical system and shield gas can be used for welding most metals, ranging from steel to zirconium. The rate of welding is extremely fast limited only by the rate at which job can be fed to the welding machine. The quality of weld can be superb with component rejections just eliminated, leading to indirect coservation of energy.

2.3.3 Machining. A detailed description of the various energy efficient machining processes is given in [6].

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MAINTENANCE PROBLEMS IN POWER PLANTS IN LIBYA:

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ABSTRACT:

The maintenance problems in the power plants in Libya is one of the most important subject of concern. The objectives of the maintenance in any operating plant is to produce power with minimum cost and down time. The main factors on which maintenance depends are maintenance organisation structure, spare parts inventory labour force and maintenance system applied. These are discussed in detail.

The important points have been suggested for good maintenance in the concluding remarks.

INTRODUCTION:

The electric energy generation is considered to be an indication of civilization progress. It covers the demand of energy required in the development of agriculture, factory, domestic use which increases the production in that field and then it leads to a good economy and self independency.

The evolution of the oil fired power plant industry has brought about big changes in the function of plant engineering. Present day production machines and processes have received all recognition from their forebears. They have become complex, intricate and incorporate in some of the most advanced engineering techniques. Electronics, hydraulics and pneumatics have come to share in the replacement of conventional electrical and mechanical system to give easier, quicker and more readily adjustable controls. Computer, automatic control methods and to some degree automation could in fact be considered as major features of the present power plant system.

The objectives of maintenance in any operating power plant is to produce power with minimum cost and down time. Therefore all the activities within the plant should be so organized and co-ordinated that their over-all effect should increase the productivity. To achieve this, the production must be carried out in the most efficient and economic manner. The unscheduled stoppages should be avoided.

Continuous efforts are being made to reduce or stabilize production cost inspite of increasing inflation, thus making increased machine utilization on economic necessity.

Modern power plants require heavy capital expenditure making 'Down time' extremely costly. To ensure maximum system availability and reliability, regular maintenance must be carried out. This maintenance must be carefully planned in conjuction with production requirement and schedules,

so that it causes the minimum stoppages and loss of production. Inadequate maintenance can lead to damage which is extremely costly not only in repairs but also in lost production.

There are many power plants spread over whole Jamahiriya in different places. Their management is run by qualified engineers, technicians who got the training on job and abroad. Therefore the plant can be operated and maintained efficiently according to manufacturers instructions.

The subject is broad and our space is restricted, selected aspects of the maintenance problems have been chosen to show how these problems are tackled. These points are summarized as below.

i) Maintenance organization structure.
ii) Spare parts inventory.
iii) Labour force (available and required).
iv) Maintenance system applied.

MAINTENANCE ORGANIZATION STRUCTURE:

Maintenance organization of any system is a structure of working relationship to proceed further the objectives of the enterprize. Production department are depending more and more upon the skills and organisation of the maintenance department and it is accepted that the maintenance is now a specialized fuction of growing importance and size. Good organization structure provides the most effective use of facilities and man power in order to secure the desired results at lowest possible cost.

Fig. (1a) Illustrates the organization structure of General Electric Corporation of Jamahiriya.

Fig. (1b) Shows production department which is responsible for maintenance in all the power plants. The survey of West Tripoli power station was made. Its organization structure is shown in Fig. (1c).

The list of contents in Fig. (1a and b) is as follows.

1. Chairman of Corporation.
2. General Administration of Production.
3. General Network and Controls.
4. General Purchasing, Stores and Servicing.
5. General Administration, Finance and Personnel Affairs.
6. General Administration Planning and follow up.
7. Head of Benghazi Branch.
8. Head of Sabaha Branch.
9. General Administration Manufacturing.
10. Manager Tripoli Power Station.
11. Manager Benghazi Power Station.
12. Manager Sabha Power Station.
13. Manager Technical Deptt.
14. Programming and Overhauls Deptt.
15. Technical Development Deptt.
16. Projects Departments.
17. Plant Managers.
18. Spare Parts and Supplies Deptt.
19. Fuel Deptt.
20. Desalination Deptt.
21. Central Maintenance Deptt.
22. Diesel Deptt.

SPARE PARTS AND INVENTORY:

A frequent situation met in recent power plants is the insufficient intial supply of spare parts and of equipments needed for correct maintenance. In sufficient availability of spare parts leads often to long shutdown periods, the lack of suitable tools often prevents to carry out correctly the maintenance operations. To over come this, large stocks of spares are often held. This policy can prove equally expensive. Storage space is of prime importance. Clerical and manual labour is needed to administer the paper work and to check the stocks. All the time spares are held in stores, keeping capital idle, increasing over-head cost. Thus balance between the extremes of low stock and high stock level must be established. This will provide an acceptable measure of safety and less costly.

In most power generating plants the spares and stores required by the maintenance department can be devided into the following categories.

1. Spares:
   a) Programme Spares:

      Spares and materials required for the scheduled or planned work contained in the maintenance programme.

   b) Break Down Spares:

      Spares held as an insurance against the unexpected break down of parts. As planned maintenance progressed, so the number of these spares would decrease.

   Some of the spares in both the above categories are ready for use.

2. General Maintenance Stock:

   Valves, piping, Flanges, electric cables, switches etc.

3. Consumable Stores of Minor Nature : (Nuts, Bolts, etc).

4. Tools and Equipment: (Specialized tools and equipment, lifting gears, chains etc) .

In variably the items contained in categories 1a and 1b have the greatest effect on the maintenance programme and are costly also.

However by applying good inventory control system, ensures that sufficient but not excessive spares and materials are available when they are needed. Before instituting the inventory control system, a proper decesion of spare parts and the level of each should be fixed. Manufacturer usually issue lists of recommended spares with their equipment.According to the information extracted from the maintenance programme, a offer can be made for different spares.

LABOUR FORCE (required and available)

There has been greater technical advancement in the last decade in the whole previous span of engineering. Modern power generating plants are becoming more and more complex. To keep pace with these developments, maintenance is demanding the application of new skills and techniques in

areas which were preveously considered beyond the scope of maintenance personnel. If the maintenance department is to fulfil its proper function in the plant, then its personnel must be trained to meet current needs and future requirements.

Training should not be a "ONCE ONLY" event like the situation in Libya, but a continuous process designed to increase the individual potential of maintenance and to form them a technically qualified well organized efficient team. Training need not always be of a purely technical or specialist nature but the background of the subjects like maintenance techniques, organization, methods should be taught. This enables a person to understand the reason for and the purpose of his efforts."Know how" together with "know why" promotes awareness and a person interested in his job will do it better.

The success or otherwise of any maintenance plan, no matter how well conceived, will be influenced directly by the performance, skills, and attitude of the staff. As much consideration should be given to the human element of the plan as is given to the material elements.

Man power planning may be limited to the men requirements for future project or production process while at the other end of the scale it involves all aspects of the man power requirements recruitments, selection, promotion and integrate them into the overall Company policy.

A realistic man power plan offers a frame work within which decisions and changes can be made with the assurance that they are always directed towards agreed objectives.

Man power requirement, selection, utilization and training and primary areas which are usually within the scope of departmental management and are good practical basis to initiate a plan. Changing conditions and circumstances in any of the areas will affect the other. Therefore a close relationship should be maintained and sufficient flexibility should exist to accommodate and compensate for changes that may occur without altering materially the ultimate objectives. Irrespective of any apparent success of the plan, a periodic view is necessary to confirm its continuing validity with the company's latest policies and aims.

The objectives of the maintenance plan must be transferred into persons, trades and occupations. However from detailed analysis of maintenance schedules programmes, present and future plans. It should be possible to assess realistically the number of persons and various types of trades and occupations that constitute the ideal maintenance team to accomplish the maintenance work.

An ideal man power standard both practical and economical is required to measure comparison and target for future. An inventory of the present staff and their respective occupations, highlight area of divergence, understaffing or overstaffing can be noted for future action.

The maintenance staff is the plants most valuable asset like other assets needed to meet specific work. The needs must be defined precisely at the time of filling vacancy, so that a right person is selected.

MAINTENANCE SYSTEM APPLIED:

The respective functions of mai[illegible]es and operation of modern power

generating plants are so inter-related that it is no loger possible or desirable to consider each as separate, isolated elements. It is therefore important that both the maintenance and operation are considered and planned on a unified basis with the object of achieving the minimum over-all production cost.

The following maintenance systems are generally applied.

Replacement, instead of maintenance system:

Power plants, using some small, easily replaceable and cheap equipment may find that the cost of repair exceeds the cost of replacement. Alternatively technological advancement causes much equipment to become obsolete rapidily, consequently, it is not designed to last when it fails, it is out of date and may be replaced with modern equipment. Many items are impossible to repair, while other items are designed not to be repaired. Their virture lies in the cheapness.

Planned Replacement:

This system may be applied in many branches of industry, particularly those in which the equipment operates as an individual unit, small power plants, machine tools etc. Good quality equipment is purchased and only basic maintenance (lubrication, servicing and adjustment) is carried out to keep it in good condition. It is then sold, traded in or scrapped before it looses its operational efficiency, when breakdowns and failures can be expected or when expensive replacements and overhauls are required. This system can reduce down time caused by break downs, prevent costly overhauls and minimize maintenance. It enables a company to obtain continually the advantages of modern equipment.

Breakdown Maintenance System:

Many items of plant and equipment operate as individual unit, so their failure would not immediately or greatly affect the overall production process or constitute a safety hazard. The cost of preventing their failure may be more than the cost of breakdown. In these circumstances, it is justified financially to allow the equipment to breakdown before carrying out any maintenance (lubrication and monor servicing expected).

Preventive Maintenance System:

When process is continuous or highly automatic, modern power plants, chemical plants, oil refineries, the cost of lost production due to breakdown. Can be extremely high. The failure of small piece of equipment can stop the whole process. Alternatively the failure of other types of equipment boilers, pressure vessels , lifting gear can be dangerous. The aim of preventive maintenance is to affect the work of inspection, servicing and adjustment so that the failure during operation can be prevented.

CONCLUDING REMARKS:

On the study and analysis of the power plants in Libya, these following points are recommended for future consideration.

a) The sufficient supply of spare parts and equipment must be there, otherwise insufficient availability of spare parts leads often to lonng shutdown periods, the lack of suitable tools prevents to carry out correctly the maintenance operation. A training for technician specialized in spare parts to be foreseen. There is frequent need of additional means

for maintenance such as tools, metrology, handling systems and workshop equipments.

b) For having good maintenance is to have good operation practices, by a suitable training of operators.

c) Training of the maintenance personel should not be in mere maintenance technology of equipment itself but also training in the maintenance methods, procurement and management.

d) Though the training abroad are very expensive, even then it should be at the job itself and also in the abroad. This should be kept in mind that a beginner should not be sent abroad for training but a person having preliminary experience in operation and maintenance.

e) A perfect cleanliness is a part of maintenance. A regular program of frequent survey, inspection of equipment to watch and report every anomaly such as leak, noise or heating and smell. There must be regular programs of lubrication and cleaning of various piping circuits, filters etc.

f) An organization of maintenance always needs to be improved simplified and completed according to the situation. Temptation should be avoided and the change in the system should be brought gradually.

g) Data processing unit can be used for perfect planned maintenance and also for spare parts, controls and man power planning etc.

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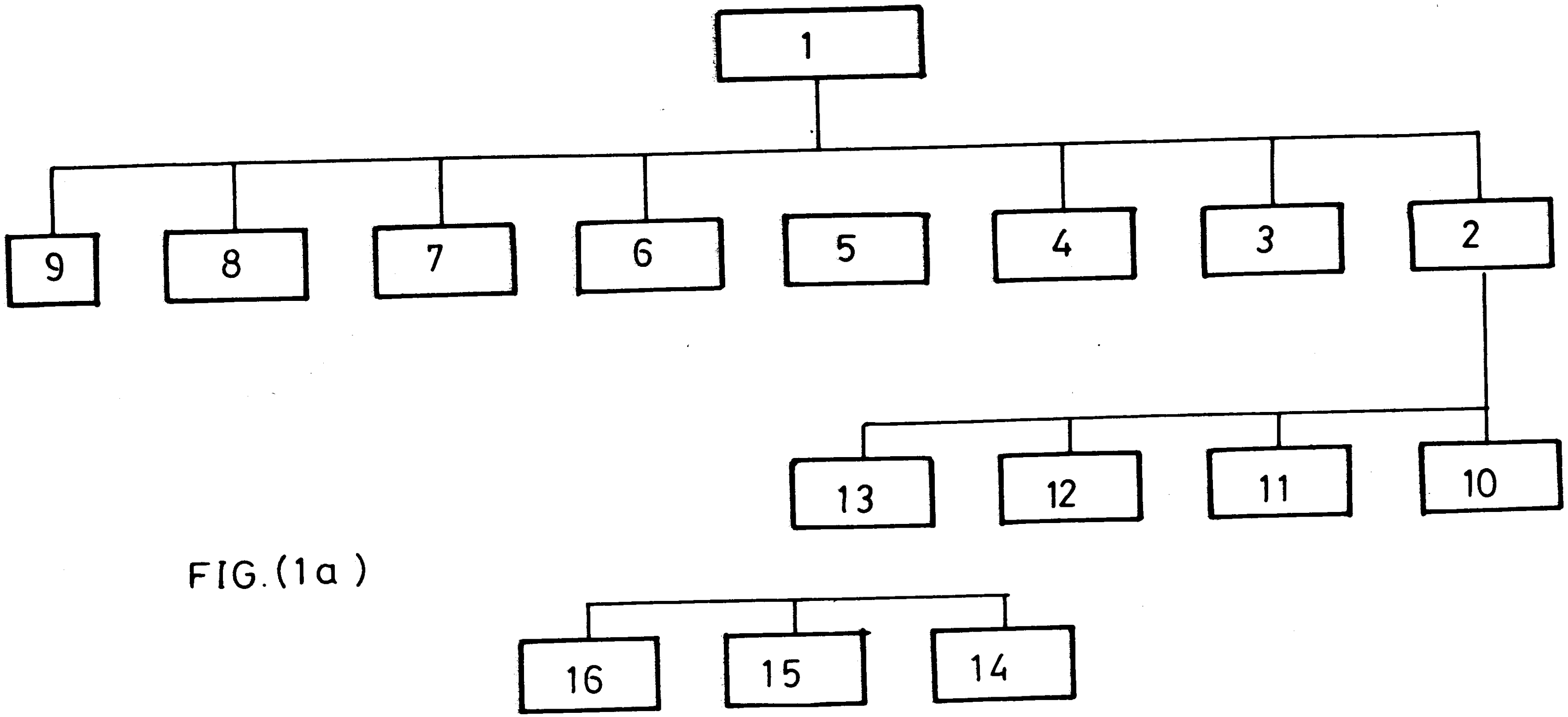

FIG. (1a)

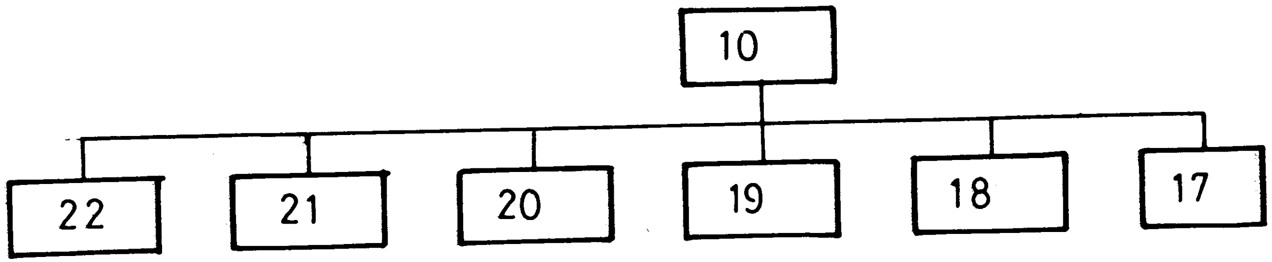

FIG. (1b)

ORGANIZATION STRUCTURE OF ELECTRIC CORPORATION
JAMAHARIA

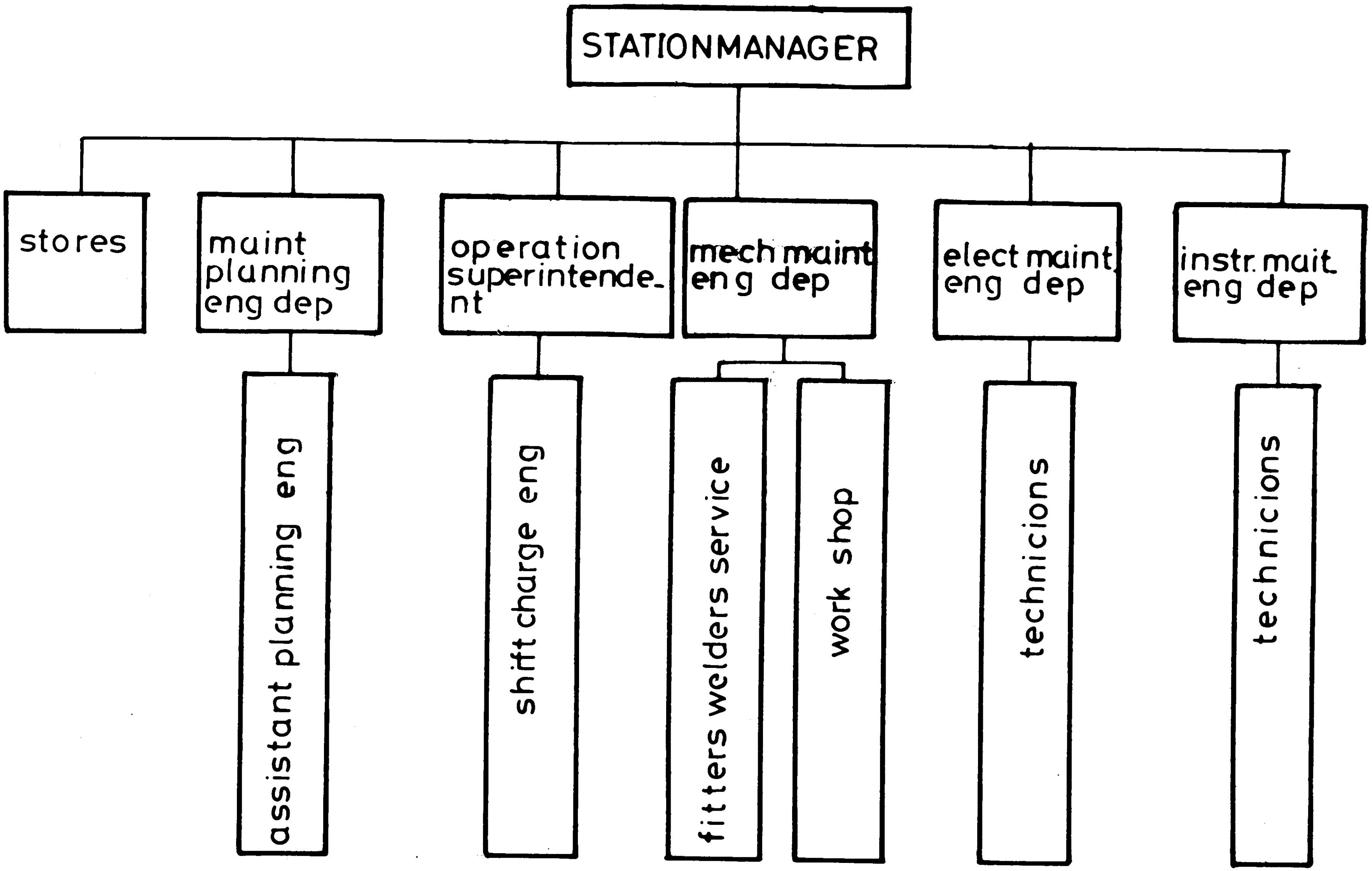

FIG.(1c) ORGANIZATION STRUCTURE OF WEST TRIPOLI POWER STATION

VARIABLE STRUCTURE CONTROLLERS FOR AGC OF AN INTERCONNECTED POWER SYSTEM

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ABSTRACT

The paper deals with the analysis of automatic generation
control of a two-area reheat thermal system considering vari-
able structure controllers. Investigations reveal that the
system dynamic performance can be significantly improved by
blocking the supplementary control action till primary con-
trol action is completed following disturbance. Investi-
gations also show that the controllers based on simple vari-
able structure logic provide much superior dynamic perfor-
mances as compared to conventional fixed structure controllers.

INTRODUCTION

A lot of work has been reported in the past pertaining
to automatic generation control (AGC) of large interconnected
power systems. Net interchange tie-line bias control strategy
has been widely accepted by utilities. The controllers so
designed regulate the area control errors (ACE) to zero.
Basically these are fixed structure controllers. Recent
literature [2-6] on AGC shows that an attempt has been made
to apply variable structure controllers (VSC) to AGC problem
orginally proposed in ref. [7]. The variable structure con-
trollers have been used to enhance the dynamic performance of
the AGC systems. The variable structure controller switches
from one structure to other according to an apriori switching
logic. This facilitates combining the useful properties of
each of the structures and possessing new properties not pre-
sent in any of the structures used. The VSC possesses several
attractive advantages, viz., high speed of response, good
transient response, insensitiveness to variation in the system
parameters and independence of changes of external distur-
bances and simplicity of physical realization.

Bengiamin & Chan [2] and Chan & Hsu [3] have obtained variable structure controllers for AGC based on sliding mode concept. However, the design procedure is quite involved. Kumar et al. ., [5] have analyzed the AGC problem using VSC. The structure suggested by them is quite simple. Conceptually the approach suggested by them is quite powerful in improving the dynamic performance of the system. However, they have not optimized the gain settings of the controller. Further the supplementary controller in an area comes into action only after the fast primary controller has completed its function [8].

Inview of the above the main objectives of the present work are:

(1) To study the effect of delay in initiating the supplementary control action on system dynamic responses.

(2) To investigate the dynamic performances of the AGC system considering variable structure controllers and to compare these with those obtained with conventional controllers.

SYSTEM INVESTIGATED

The AGC system investigated comprises two equal-area thermal system having reheat turbines. A step load perturbation of 1% of nominal loading has been considered in area-1. Nominal parameters of the system are given in Appendix-A. Fig. 1 shows the small perturbation transfer function block diagram of the system.

Dynamic Model in State Variable Form

The dynamic model in the state-space form is written as

$$\dot{X} = AX + BU + \Gamma p \tag{1}$$

X,U and p are the state, control and disturbance vectors respectively. These are defined as :

$$X' = [\Delta F_1 \;\; \Delta P_{g1} \;\; \Delta P_{R1} \;\; \Delta X_{E1} \;\; \Delta P_{tie1} \;\; \Delta F_2 \;\; \Delta P_{g2} \;\; \Delta P_{R2} \;\; \Delta X_{E2}]$$

$$U' = [\Delta P_{C1} \;\; \Delta P_{C2}]$$

$$p' = [\Delta P_{D1} \;\; \Delta P_{D2}]$$

A,B and Γ are system matrices of compatible dimensions and are function of system parameters and operating points. Area control error (ACE) is sampled at every two seconds. ACE remains constant between two consecutive sampling instants. System dynamic responses are obtained using the approach suggested by Bose and Atiyyah [9]

Structure of the Delayed Integral Controller

Fig. 2a shows the structure for the delayed integral control. The control channel selection is based on the following logic.

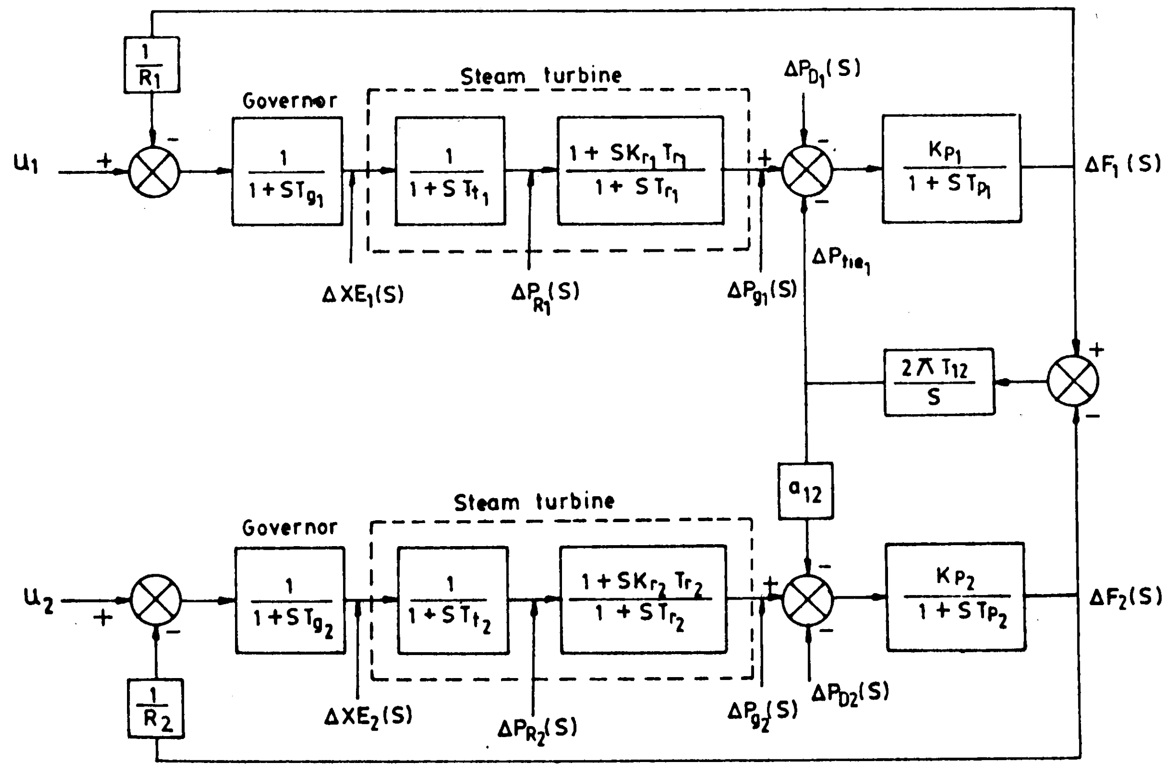

Fig. 1: Transfer function model of a two-area reheat thermal system

$$\text{If } t \leq T,\ U_i = 0\ , \quad \text{(uncontrolled)} \tag{2}$$

$$\text{If } t > T,\ U_i = -K_{Ii} \int ACE_i\ dt \ \text{(Integral control)} \tag{3}$$

where T is the response time of the governor.

Variable Structure Control System

Two control strategies using variable structure concept are investigated.

(a) Control Strategy Based on Single Proportional-Integral Sequence

Fig. 2b shows the schematic diagram of the variable structure controller (VSC). In this control strategy, the control signal is made proportional to ACE for the first part of the system dynamics and then it is proportional to integral of ACE i.e.,

$$U_i = -K_{pi}\ ACE_i \qquad \text{for } t \leq T \tag{4}$$

and

$$U_i = -K_{Ii} \int ACE_i\ dt \qquad \text{for } t > T \tag{5}$$

T is chosen judiciously by analyzing the uncontrolled response of the system.

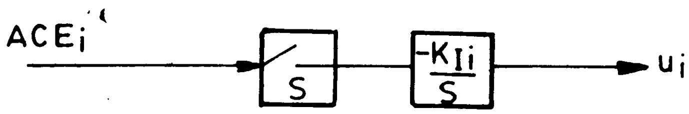

FIG. 2a

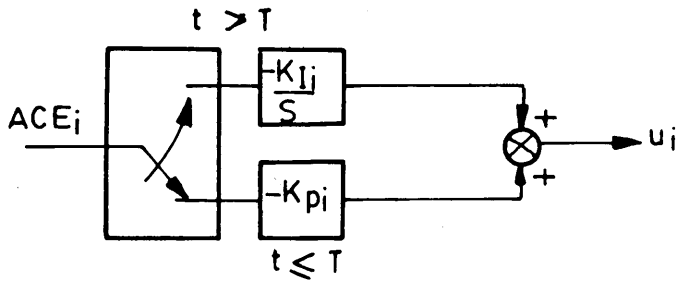

FIG. 2b

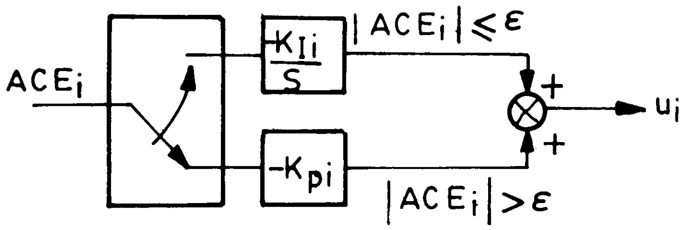

Fig. 2c

Fig. 2: Schematic diagrams for various VSC logics

(b) VSC Strategy Based on Alternate Proportional-Integral Sequence

Fig. 2c shows the schematic diagram of alternate proportional-integral type control strategy. In this control strategy, following logic is used -

If $|ACE_i| > \epsilon$, $U_i = -K_{pi}\ ACE_i$ (6)

and

If $|ACE_i| \leq \epsilon$, $U_i = -K_{Ii}\int ACE_i\ dt$ (7)

The ϵ is set equal to half the maximum transient swing of ACE_i

ANALYSIS

Delayed Supplementary Control System

An attempt is made to investigate the effect of delaying supplementary control action on dynamic performance of the system. The delay is made nearly equal to the response time

of the governor. Inorder to estimate the response time of the governor the uncontrolled dynamic response is plotted (Fig. 3). Examining the uncontrolled responses, it can be seen that the primary control action (i.e. governor action) is more or less completed in 7 seconds. Inorder to investigate the effect of delayed supplementary action, optimum integral controller obtained in ref. [1] (K_I = 0.67) is considered. Fig.3 also shows the dynamic responses considering (i) optimum integral controller and (ii) delayed integral controller. The dynamic responses with integral control action initiated after 7 seconds show that the positive overshoat is practically eliminated and the responses settle smoothly.

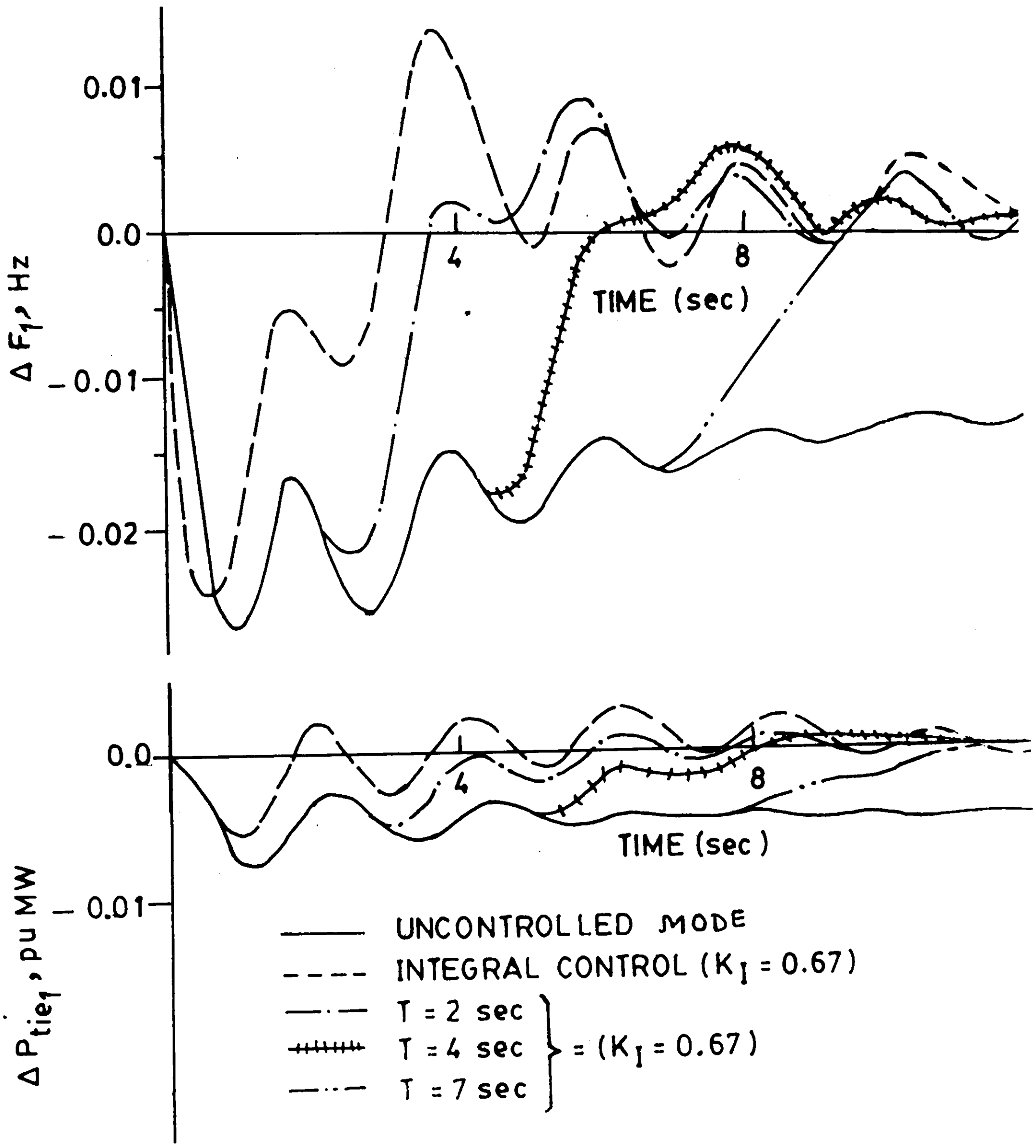

Fig. 3: Effect of delay in supplementary control action on dynamic responses.

However, the settling time remains unaffected. Dynamic responses are also shown for time delays equal to 2 and 4 seconds. As the time delay is reduced from T=7 seconds the positive overshoot increases. Hence it can be concluded that the supplementary control action if initiated, after the governor response is complete provides much better dynamic performances.

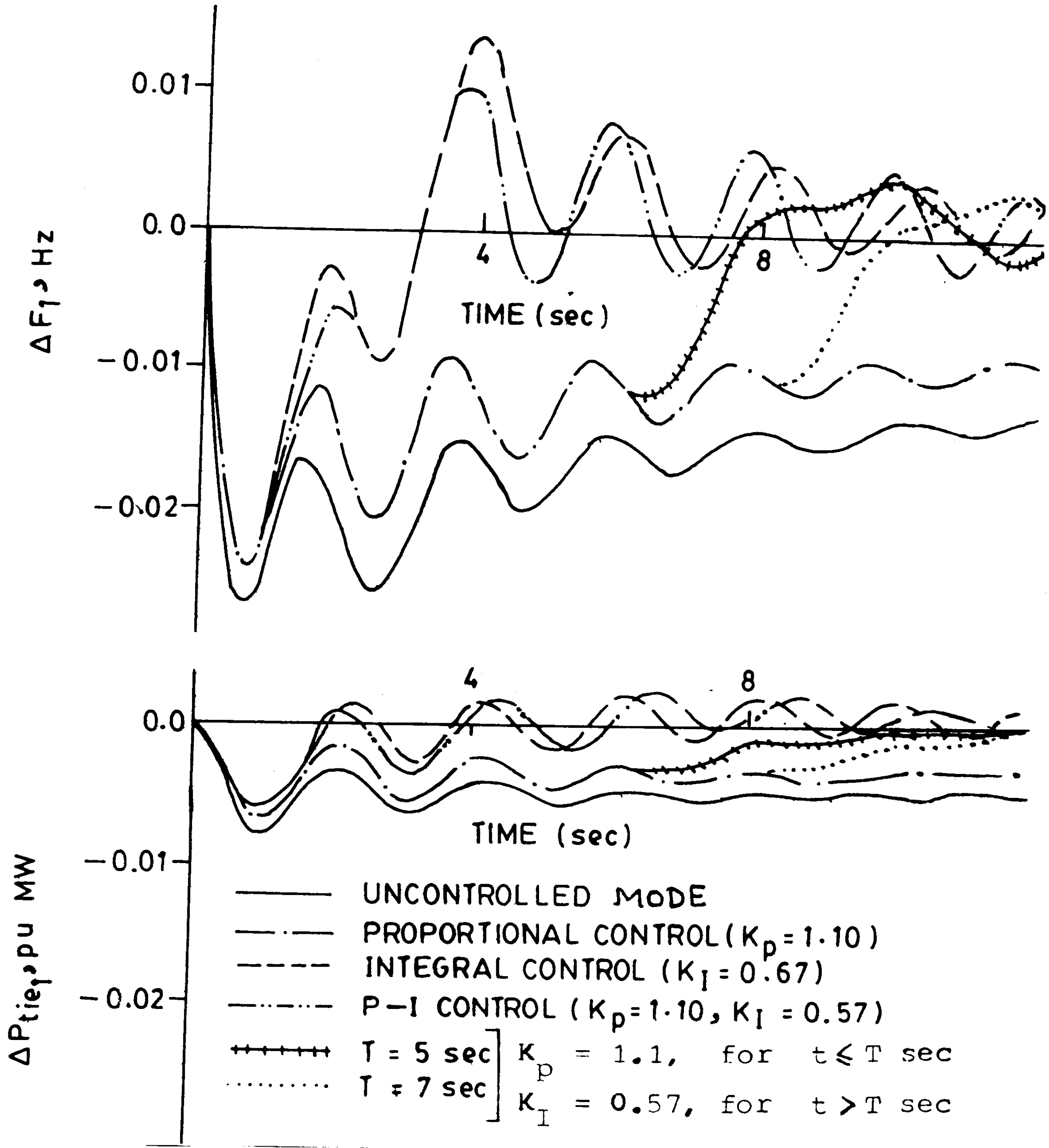

Fig. 4: Dynamic responses for different control strategies

Single Sequence Proportional-Integral Controller

Investigations mentioned in the preceding section reveal that the blocking of the supplementary control action till the primary control action is completed, enhances the dynamic performance of the system. Now an attempt is made to analyze the dynamic performance of the system considering the control strategy as given in equations (4) and (5) K_p and K_I are obtained using Integral Squared Error (ISE) technique, where T is the governor response time. Fig. 4 shows the

system dynamic responses for a step-load perturbation of 1% in area-1 for several values of governor response time T. Dynamic responses for uncontrolled mode and those with optimum P-I controller (K_p=1.10, K_I=0.57, obtained using ISE technique) are also shown.

The cost function $J = \int_0^\infty (4.7\,\Delta P_{tie1}^2 + \Delta F_1^2)\,dt$ is minimized to obtain optimum P-I gain settings.

Dynamic responses with optimum integral gain (K_I=0.67) setting are also plotted in Fig.4. Dynamic responses with proportional controller acting for first 7 seconds and then integral controller results in some improvements in dynamic responses. Thus it can be recommended that a judicious combination of control action (i.e. proportional first and then integral) would improve the dynamic responses. The optimum value of T may be obtained by trying a few feasible values of T.

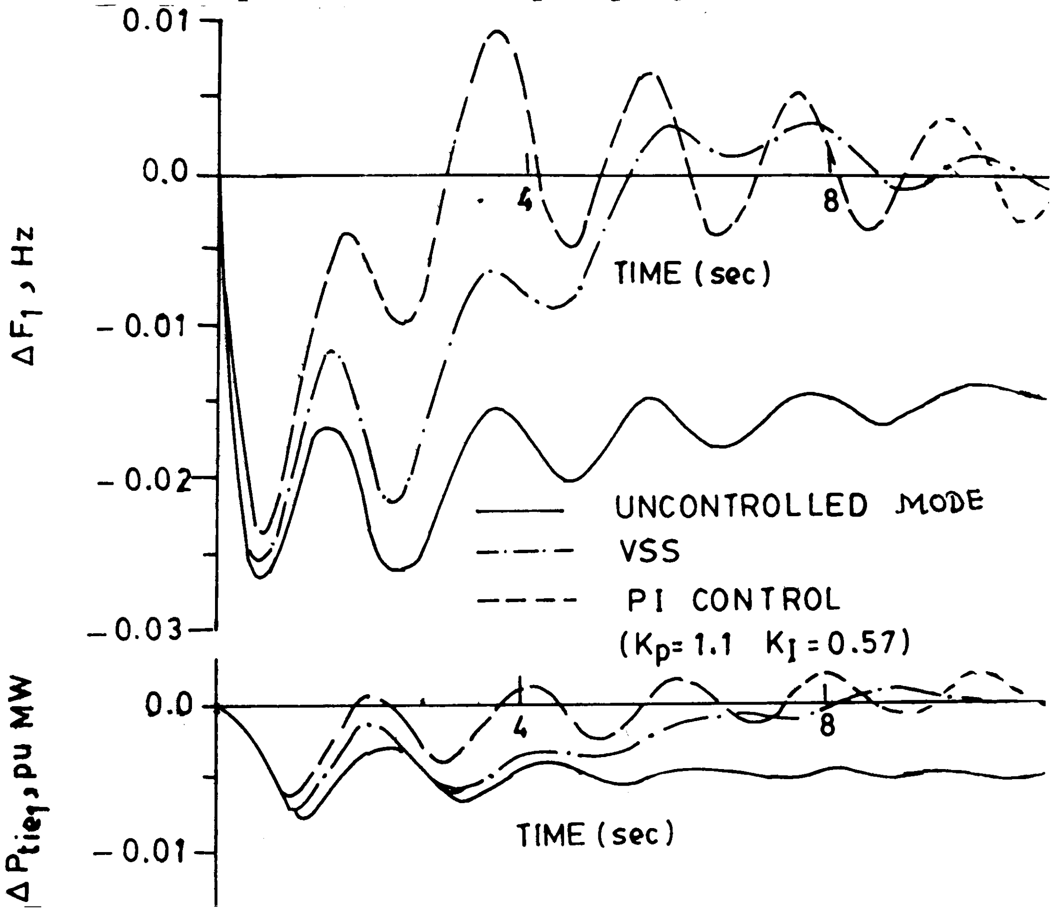

Fig. 5: Dynamic responses with P-I and VSS control Strategies

Alternate Proportional-Integral Sequence

Above investigations reveal that dynamic responses are improved considerably even with single proportional-integral control sequence. Further studies are made using the control logic given in Eqns. (6) and (7).

Fig. 5 shows the dynamic responses (ΔF_1, ΔP_{tie1}) with the VSC strategy. Dynamic responses considering optimum P-I controller and uncontrolled mode are also shown. It is clearly seen that there is a considerable reduction in setting time, and positive overshoot with VSCstrategy as compared to

those obtained with optimum P-I control strategy. In all probability one may succeed in further improving the dynamic responses by trying a few values of ϵ and thus obtaining optimum value of ϵ . K_p and K_I as obtained for P-I controller were used with VSC strategy.

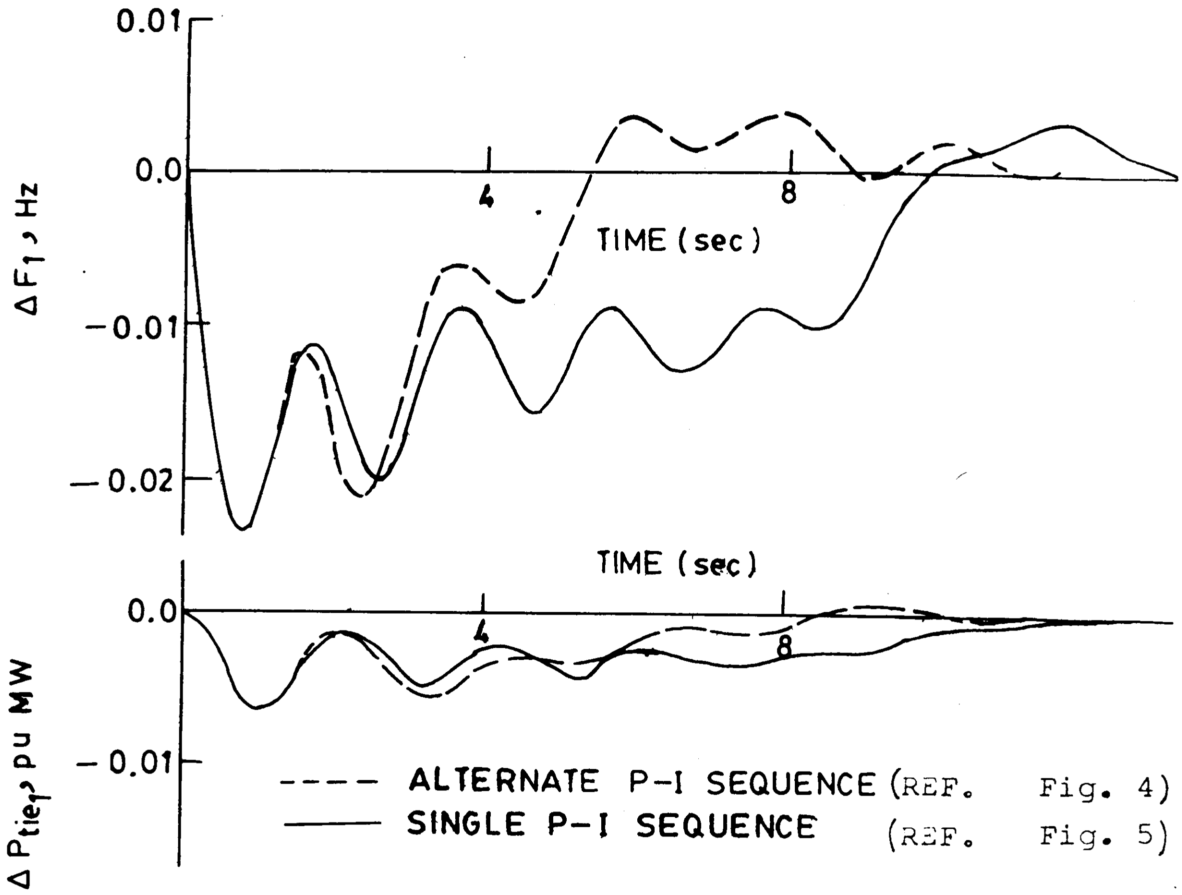

Fig. 6: Dynamic responses for two different control strategies

Comparison of Single P-I Sequence and Alternate P-I Sequence Controllers

Fig.6 shows the dynamic responses of the system considering (i) Single P-I sequence and (ii) alternate P-I sequence controllers. It is clearly seen that alternate P-I sequence controller provides much better dynamic responses interms of settling time, time error and inadvertent interchange accumulations - as compared to those obtained with single P-I sequence and should be preferred.

CONCLUSIONS

Following are the significant contributions of this paper:

(1) There is a considerable improvement in system dynamic performance with delayed integral control action as compared to the conventional integral control. The time delay chosen judiciously, results in improved dynamic performances and avoids unnecessary interaction between primary and supplementary control loops.

(2) The simple variable structure control strategy where proportional supplementary control action takes place if $|ACE| > \epsilon$ and integral control action, when $|ACE| \leq \epsilon$ improves the dynamic responses significantly interms of settling time and positive overshoot.

(3) Investigations carried out considering alternate proportional and integral VSC results in significant improvement in dynamic performances as compared to that with single proportional integral sequence controller.

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APPENDIX - A

The nominal system parameters are :

$f = 60.0$ Hz

$K_{p1} = K_{p2} = 120.0$ Hz/puMW, $T_{p1} = T_{p2} = 20.0$ secs.

$T_{t1} = T_{t2} = 0.3$ sec., $T_{g1} = T_{g2} = 0.08$ sec., $H_1 = H_2 = 5.0$ secs.

$T_{r1} = T_{r2} = 10.0$ secs, $K_{r1} = K_{r2} = 0.50$

$R_1 = R_2 = 2.40$ Hz/puMW

$B_i = \beta_i (i = 1, 2)$, $D_1 = D_2 = 8.33 \times 10^{-3}$ pu MW/Hz,

$P_{tiemax} = 200$ MW, $P_{r1} = P_{r2} = 200$ MW

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AIR POLLUTION DISPERSION

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ABSTRACT:

Air pollution in the atmosphere is mainly a problem of diffusion/dispersion of gas/particulates under the prevailing wind conditions. However, the emission rates of different sources, and their spatial locations play a great role in defining the air quality conditions at large. The modern way to understand this problem using digital computers is a great scientific tool. The Gaussian diffusion model is a simple way to get some air quality information but many other sophisticated models can be used for different conditions.

1. INTRODUCTION:

Ail pollution represents one of the most serious problems to mankind. If the trend of increasing energy consumption continues, more and more emission sources will be created which means more substances will be dumped into the atmosphere. The extent of the damage caused by man-made emissions is not fully understood. However, acidification of lakes (e.g. Sudbury, Canada and Southern Norway) have been unequivocally linked with acidic deposition in the form of sulphur dioxide and its oxidation product sulphuric acid. Acidification attacks the soil, damage plants and trees and plays a major role in the loss of fresh water fish in some lakes. It can also spoil metals and other exposed material to polluted air. In general the harm caused by air pollution to human and animal is yet to be assessed.

2. NATURE OF THE PROBLEM:

Air pollution can be divided into three major categories: (1) Gaseous (2) Liquid (3) Solid.

Atmospheric trace constituents (ATC) is either natural or man-made (antropogenic).

Oxygen and Nitrogen represent two gases present by nature in the atmosphere. Volcanoes and other natural eruptions produce solid small particles during active times. Natural processes produce: fog, cloud and rain through

the process of condensation of water vapour on nuclei. Antropogenic emissions however, produce ATC in the above three categories. Carbon dioxide is an example of ATC with a residence life time of 2-5 years. Due to sharp increase of energy consumption and burning of fossil fuels, CO_2 concentration in the atmosphere started to rise. In 1976 CO_2 concentration was 330 ppm (V) compared to 290-300 ppm (V) in the pre-industrial era. This concentration level is expected to reach 400 ppm (V) by the turn of the century. The increase of CO_2 levels can cause a trap of solar energy close to earth which can lead to temperature rise (the green house effect). This may lead to change in world climate. Sulphur dioxide is another major ATC with a variable concentration from region to region. It has a residence life time of the order of days to weeks. Due to antropogenic emissions from the burning of sulphur bearing fossil fuels and the smelting of sulphide ores, man produces some 130 million tonnes of this gas every year. Volcanoes release only 4 million tonnes per year.

The transformation of sulphur dioxide to solid sulphate particulate in the atmosphere produces yet another more serious pollutant. The oxidation rate of SO_2 to sulphate range from 0.1 to 10% per hour depending on the presence of catalysts, clouds, reactive photo-chemical products and ozone. These solid particulates can now be transported to even greater distances. Not only that but the accumulation of these suspended particulates can upset the radiation balance which may cause cooling. The next pollution problem comes from the solubility of SO_2 and sulphate particulates in the presence of water vapour. When this process of condensation occurs we get either the photo-chemical smog or acid rain.

Chlorofluoromethanes (Freon) $CFCl_3$ and CF_2Cl_2 are also another two types of pollutants found as ATC. They are linked to human sources, mainly from aerosol propellant and refrigerants industries. These gases are inert in the troposphere and direct photochemical destruction requires short wave radiation. This process will only be effective in the stratosphere (above 30 km from ground). The accumulation of these pollutants may disturb the ozone layer around the earth which lead to the upset of nature balance. Other pollutants (gas, liquid, solid) are also present in the atmosphere and the degree of concentration may vary from place to another. Due to major construction projects of factories and highways pollution of different kinds can be present. Some of these pollutants can be very hazardous to human and animal health. They vary from chemical vapours to heavy metal particulates or simply toxic gases. The problem becomes more serious whenever these industrial areas, power generation plants or highways are close to residential areas. Not only that but wind conditions and the properties of air to encourage transport of pollution can play a major part to make the problem more serious. For example, the effect of different heating and cooling of land and water surfaces and the air above them produces the so-called sea or lake breeze (when land is warmer than water) and land breeze (when water is warmer than land). In this case continuous costal fumigation may be present which will cause a pollution problem to the nearby areas. Another problem which occurs because of the accumulation of air pollution at certain location is the absence of night-time inversion (Fig. 1) over urban areas. This so-called "Pollutant dome" will also encourage vertical motion of pollutant to both the urban area and the nearby countryside.

3. AIRPOLLUTION DISPERSION:

The above discussion shows that air pollution is mainly a problem of diffusion/dispersion of gas/particulates in the atmosphere.

Dispersion of pollutant, however will depend on wind conditions, the degree of turbulence, temperature stratification and the surface roughness at ground level. Temperature stratification can be estimated from the variation of temperature with height. The decrease of temperature with height $-\partial T/\partial Z$ is called the lapse rate. Atmospheres with laps rates of above $10^{\circ}C\ Km^{-1}$ are called "adiabatic". Superadiabatic atmosphere is considered unstable since vertical motion (descent or ascent) is encouraged. In sub-adiabatic atmosphere vertical motion is less and its case is considered "stable". Inversion mainly occurs at night with strong stability. Fig.(1) shows the effect of different stability regions on the diffusion of pollutants from a stack.

The lapse rate, however is only a rough index to turbulence. The structure of atmospheric turbulence (eddy size,....etc.) and its effect on pollutant-puff dispersion will depend on the relative size of the atmospheric eddies and the pollutant puff size. If the atmospheric eddy size is smaller than the pollutant puff, the puff will grow slightly and decreases its concentration. This means slow diffusion/dispersion process or bad air-quality. On the other hand if the eddies are larger than the puff, the puff will experience transport and less mixing. If the eddies are of the same size as the puff, the puff will diffuse rapidly. The important fact is that information about the mixing height remains the easiest way to know the condition of atmospheric stability. This will help in applying computer models to predict the air quality at certain place and the ground level concentration. Measurements of variation of temperature profile above ground level can lead to the estimation of the mean mixing length at different locations (e.g. Holzworth, 1972, and Portelli, 1977).

4. a) THE GAUSSIAN DIFFUSION MODEL

Computer models are considered an important tool to predict the air quality condition at certain location. This can help governmental authorities to take action if the levels of pollutants are considered high. Computer models to predict air quality vary from simple single source model to very sophisticated models which take all pollution parameters into consideration i.e. physical, chemical, spatial, temporal, ...etc.

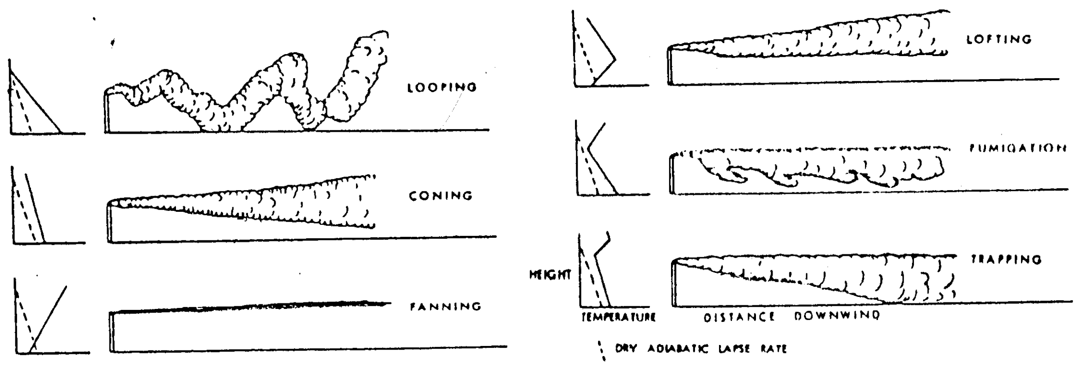

Fig. 1. Variation of Pollutant Concentrations
Due to Meteorological Variations

The following is a simple model which relates the pollutant concentration C(x,y,z) downwind of an elevated point source over a flat terrain. The model is limited to with a distance x where the plume first encounters the top of the mixing layer. The model will be best for studying micro scale (less than 10 Km) air pollution dispersion problems (e.g. near large point sources, highways, airport runways,...etc).

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z U} \exp\left\{-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right\}\left\{\exp\left[-\tfrac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\tfrac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Where:

C(x,y,z)	: pollutant concentration downwind; $\mu g.m^{-3}$
Q	: pollutant emission rate (source strength); $g.s^{-1}$
U	: wind speed at height H; $m.s^{-1}$
σ_y	: horizontal dispersion coefficient; m
σ_z	: vertical dispersion coefficient; m
x	: downwind distance; m
Y	: horizontal (crosswind) distance; m
z	: vertical distance; m
H	: effective stack height; m, $H = h + \Delta h$
h	: Stack physical height; m
Δh	: Plume rise; m

Horizontal and vertical dispersion coefficients σ_y, σ_z can be estimated using formulas recommended by Briggs (1974). These formulas are atmospheric stability dependent and each case follows a stability category defined by Pasquill and Gifford. These categories carry the symbols A, B, C, D, E and F. Class A is the most unstable, class F is the most stable and class D is considered neutral.

The stability categories are defined as a function of surface wind speed (at 10 m), temporal variation (day or night), the condition of incoming solar radiation (strong, moderate, slight) and the cloud condition at night.

The following table shows the recommended equations by Briggs (1874) for open country conditions in the range 100 m $< x <$ 10,000 m micro-scale studies .

Table 1

Pasquill Stability Category	σ_y	σ_z
A	$0.22\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.20\,x$
B	$0.16\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.12\,x$
C	$0.11\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.08\,x\,(1+0.0002x)^{-\frac{1}{2}}$
D	$0.08\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.06\,x\,(1+0.0015x)^{-\frac{1}{2}}$
E	$0.06\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.03\,x\,(1+0.0003x)^{-1}$
F	$0.04\,x\,(1 + 0.0001x)^{-\frac{1}{2}}$	$0.016x\,(1+0.0003x)^{-1}$

The evaluation of the effective stack height H depends on the plume rise value Δh.

There are a number of formulas used to predict Δh. Most of these formulas describe Δh as a function of Q, the heat emission rate in MW or $Cal.s^{-5}$ and the wind speed U. In general, however Δh depends on terrain roughness and the atmospheric turbulence structure.

The following are some equations commonly used by atmospheric scientists to evaluate Δh:

a) Holland (1953) formula:

$$\Delta h = (1.5\, V_s\, d + \overline{410^{-5}}\, Q)/U$$

V_s : Stack gas exit velocity; $m.s^{-1}$

d : internal stack diameter at exit; m

Q : heat emission rate; $Cal.s^{-1}$

b) Bringfelt (1968) formula:

Depending on the downwind distance, Δh is given by

1) $\Delta h = \frac{103}{U} Q^{0.39}$ for $x \leqslant 250$ m

2) $\Delta h = \frac{167}{U} Q^{0.36}$ for $250 < x \leqslant 500$ m

3) $\Delta h = \frac{224}{U} Q^{0.34}$ for $500 < x \leqslant 1000$ m

The heat emission rate Q is in MW

c) Moses and Carson (1968) formula:

$$\Delta h = \tilde{A}\left(-0.029 \frac{V_s\, d}{U} + 5.35 \frac{Q^{\frac{1}{2}}}{U} \right)$$

Where $\tilde{A}$ reflects the stability condition,

$\tilde{A}$ = 1.08 neutral

$\tilde{A}$ = 0.68 stable

$\tilde{A}$ = 2.65 unstable

Other formulas can be found in the reference list [Csanady (1961), Briggs (1969, 1971, and 1972)].

The maximum ground level concentration C_{max} is given as

$$C_{max} = \frac{2Q}{\pi . e . U} \left(\frac{\sigma_z}{\sigma_y} \right) \frac{1}{H^2} \quad (2)$$

where $e = 2.718$

This equation indicates that for constant emission at wind speed U, C_{max} inversely proportional to H^2. This maximum occurs at the distance x where $\sigma_z = H/\sqrt{2}$

The ground level concentration (centerline)

$$C(x,0,0) = \frac{Q}{\pi \sigma_y \sigma_z U} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

4. b) Limited Mixing Condition:

One of the important problems faced by pollution control workers is the "trapping" plume or limited mixing case (Fig. 1). The maximum ground level concentration under limited mixing condition is given by:

$$C_{max} = \frac{Q}{\sqrt{2\pi}\,\sigma_y LU} \qquad (3)$$

Where L is the mixing height, m.

This maximum occurs at a distance 2x, where x is the distance at which $\sigma_z = 0.47$ L.

To calculate C_{max} we need to get the mixing height so we can estimate the horizontal dispersion coefficient σ_z. This value will correspond to a value X and σ_y can be estimated from Briggs formulas.

From the above simple model, many other realistic models are derived and used by environmental authorities around the world (e.g. Atmospheric Environment Service, Canada, Environmental Protection Agency (EPA), U.S.A, etc.). The basic ideas presented in the model above are also used in the currently available models. However, we should mention that the accuracy of the observed maximum downwind ground-level concentration value is expected to be within 10-20% of the calculated value for a surface level source and within 20-40% for an elevated source. Extensions of the basic point-source model to urban dispersion should tend to produce concentration estimates with smaller statistical variations because the effect of one or more of the uncertainties are usually removed in the process. Selected list of available air quality computer models is presented at the end of this paper.

5. APPLICATION OF COMPUTER MODEL:

Micro-scale application of a modified Gaussian computer model is well underway for some limited locations in the Middle-East. However, the lack of information about wind and mixing length will postpone results to some other time. In the case of the Libyan case study, major emission sources are present in Tripoli, Khoms, Misurata and Benghazi. Preliminary study showed that these sources don't present a serious pollution problem to major residential areas. However, with the gradual growth of major industries in the sea shore line there is a growing concern for immediate fumigation to near-by urban-areas due to sea-breeze effect. The author has some reservations however that the situation in Metropolitan Cairo is similar to that in Tripoli. When the complete results of this study will be ready, the Cairo case will be of major concern to all. The major industrial installations in Helwan and close to Cairo city plus the huge number of both private and public vehicles create a bad environment for health and properties.

It seems to me that as long as there is an increase of energy use (in one way or the other) the problem of air pollution will get worse and somehow concerned people and public authorities must flash the red light to stop major problems from happening before it is too late.

CONCLUSION:

Based on the short study presented above we recommend the following:

1) New factories and power generation stations should be located away from urban and/or residential areas.

2) Industries should be requested to use air pollution control methods.

3) Private cars should be run on un-leaded gasoline and public mass transportation should be encouraged.

4) Environmental authorities should make use of present computer models to monitor air quality at different locations and to take action for the sake of the general public health and properties.

5) Conservation of the present sources of energy and creating the practical methods to use pollution free alternative energy.

SELECTED NAMES OF AVAILABLE AIR QUALITY COMPUTER MODELS:

1) APRAC: The Standord Research Institute APRAC-1A model computes the hourly averages of CO as a function of extra urban diffusion from automotive sources in upwind cities, intra urban diffusion from roadway sources, and local diffusion within a street canyon.

2) HIWAY: An interactive program which computes the short term (hourly) concentration of non reactive pollutants downwind of roadways.

3) CDM: The climatological Dispersion Model determines long term (seasonal or annual) quasi-stable pollutant concentrations at any ground level receptor using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability for the same period.

4) PTMAX: An interactive program which performs an analysis of the maximum short term concentration from a point source as a function of stability and wind speed.

5) RAM: Gaussian-Plume Multiple Source Air Quality Algorithm. This short term Gaussian steady state model estimates concentrations of stable pollutants from urban point and area sources. Hourly meteorological data are used. Hourly concentration and averages over a number of hours can be estimated.

6) CRSTER: This algorithm estimates ground level concentrations resulting from upto 19 colocated elevated stack emissions for an entire year and point out the highest and second-highest 1-hour, 3-hour, and 24-hour concentrations as well as the annual mean concentrations at a set of 180 receptors.

7) SAI-Photochemical Model: The SAI model is a photochemical dispersion model. It not only considers the transport and dispersion of pollutants but also the transformation of HC and NO_x into photochemical oxidant pollutant. This model uses finite difference techniques over a grid of area sources to solve the classical equations of conservation of mass

which include local change, advection, diffusion, photochemical reaction and emission.

8) TEM: The Texas Episodic Model is a FORTRAN computer program which may be used to predict air pollution concentration for short time periods. An emission inventory and meteorology for an area of interest are used to create scenarios simulating the dispersion of airborne pollutants in the lower atmosphere. Concentrations of one or two pollutants may be calculated upto 2500 locations in a rectangular grid of arbitrary dimensions and uniform but arbitrary spacing between rows and columns. Up to 300 elevated point sources and 200 area sources may be input to the model and a very wide selection of meteorological inputs is available.

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Foot-note: Computer modelling information and other air-pollution data were obtained during the authors association with Environment Canada (AES,Downsview, Ontario).

PART 2

SOLAR ENERGY

JAPANESE EXPERIENCES IN SOLAR ARCHITECTURE

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ABSTRACT

An overview on the recent Japanese experiences in solar architecture is described. Most of traditional Japanese houses can be regarded solar houses of bioclimatic design, having large openings on the south facade with deep eaves. Total solar collector area in Japan amounts to more than 2 million square meters, supplying solar energy for hot water, space heating and cooling. Architectural design of solar houses and buildings has been refined and malfunction in systems reduced. Economics of solar energy systems are discussed and government subsidies are introduced. Japanese architects are gradually getting interest in designing passive solar houses and buildings. Importance of passive cooling techniques is emphasized in learning fundamentals from vernacular architecture. Interaction between nature oriented architecture and indoor environment by modern technologies is discussed.

1. INTRODUCTION

For the last several years newly constructed solar houses and buildings have decreased in number at the rate of 70 to 80% compared to the previous years certainly due to lower oil prices after ENERGEX '82 in Regina,Canada [1]. It is rather important to note, however, that energy conserving ideas are being widely understood by designers and owners so that new buildings in general are consuming less amount of energy while maintaining sufficient comfort level in indoors. Passive systems without excessive cost for new buildings are being attempted and new ideas of inviting daylight by providing atria and light shelves are coming into play as well. On the other hand traditional devices as seen in vernacular architecture are respected from the viewpoint of bioclimatic designs, as they were built in those days when fossil fuels were not available as today.

2. BIOCLIMATIC DESIGNS IN TRADITIONAL JAPANESE ARCHITECTURE

Japan is a hot and humid country as a whole, though we have a winter season for a period of three to six months depending on locality. Tradi-

tional houses in Japan have been built principally for summer and people have been suffered from the cold spell in winter. Because discomfort under the severe summer was recognized much more intolerable than cold discomfort in winter [2].

Sun shading and cross ventilation are two major concerns in house design and south facing facade is mandatory to harness the sun in winter as much as possible. Without changing the form of the house, it has been possible and easy to satisfy these fundamental requirements by providing deep eaves on the south facade with wide open sliding doors so that breeze can come through from the garden in summer and yet abundant solar radiation of lower altitude can enter into the room to warm up indoor spaces in winter. Therefore the floor plan of rectangular shape with longer side in east-west direction is quite typical.

The reason why wide opening on the south facade is typical may be explained in such a way that houses are built with timber frame construction, colums and beams holding curtain walls. Unlike modern houses, moreover, traditional houses have greater thermal mass of clay walls and natural moisture regulation mechanism of wood, straw matt and clay walls. Large roofs can avoid penetration of strong solar radiation in summer and thatched roofs is effective in evaporative cooling to make inside ceiling surface temperature lower than insdie air. On the other hand modern houses are built with nearly flat or slightly tilted roof to be resulted in higher ceiling surface temperature and this must be offset by mechanical cooling means.

Similar situation can also be seen in multi-storied buildings. Natural ventilation required higher ceiling to bring cooling effect for occupants in the buildings built fifty years ago. Whereas in modern high technology buildings have lower ceiling heights, thus making air conditioning mandatory.

Fig.1 Deep eaves and large opening of typical Japanese house

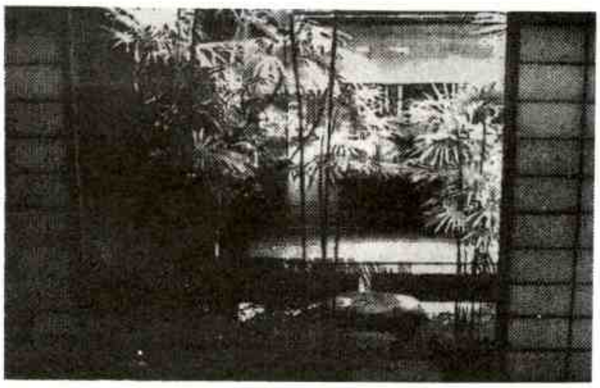

Fig.2 Living quarter of a merchant house in Kyoto

3. SOLAR THERMAL SYSTEMS INTEGRATED INTO BUILDINGS

3.1 Development of Solar Collectors

After the oil crisis many manufacturers attempted to develop new technologies of solar collectors and several of them were successfully commercialized for practical use. In the earlier stages collector arrays were simply placed in rows on flat roofs: they did not exhibit satisfactory appearance of solar architecture, though their systems might have worked well.

They can be classified into major two types: flat plate type and evacuated tubular type. Parabolic cylinder types of collector with line focus did not prove high efficiency in Japan, because diffuse component of solar radiation is rather greater in Japanese humid climate. The flat-plate collector of most common type consists of single pane of semi-tempered glass and collector plate with selective coating, being quite widely used both in residential, commercial and public buildings. Evacuated tubular collector also involves absorber with selective coating, thus suppressing both radiation and convection losses.

Total area of collectors installed on site is a good indicator to estimate actual solar contribution to the national total energy requirements. According to the statistics by Solar Systems Development Association it amounts to 2,122,011 m^2 in cumulative total since 1975 up to the end of 1987 [3]. The breakdown for the last five years shows that 80.3% of those are flat-plate collectors. It may be estimated that solar heating, cooling and domestic hot water systems with all collectors installed are supplying energy equivalent to 80,000 kl of oil per year.

It must be noted, however, that simple solar water heaters placed on the roofs of houses for domestic use are very popular in Japan and supplying larger amount of energy than that supplied by the solar systems described in the above.

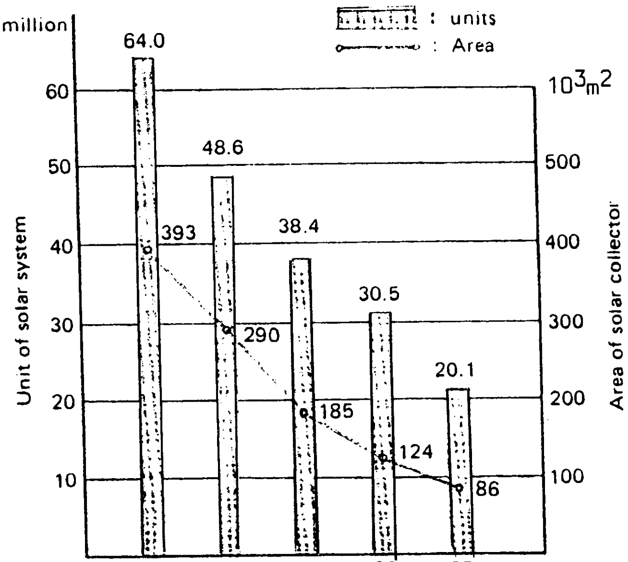

Fig.3 Sales trend of solar system and collector area

(Survey of Solar System Development Association)

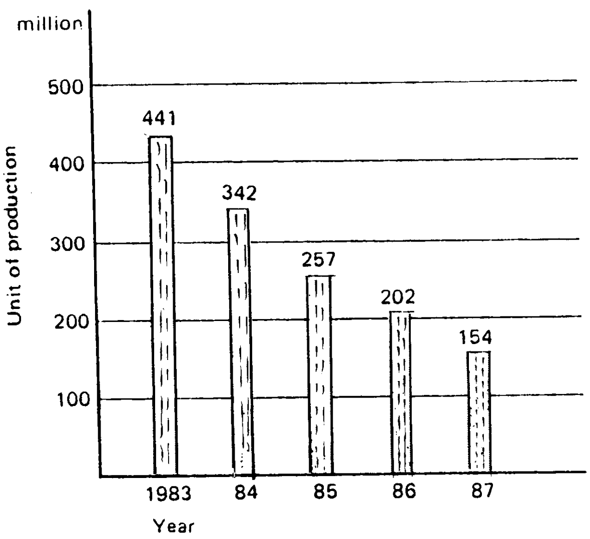

Fig.4 Production trend of solar water heater

(Survey of Solar System Development Association)

3.2 Solar Houses and Buildings with Domestic Hot Water Supply, Space Heating and Space Cooling

Table 1 show the statistics on the solar houses and buildings with domestic hot water supply, space heating and space cooling respectively. It can be seen that the numbers are decreasing year after year since 1982. This is only because of lower oil prices than experienced in the oil crises in 1973 and 1979 [3].

On the other hand the quality of solar houses and buildings actually constructed has been raised in various aspects. The cases of malfaction in

Table 1 The actual result of the installation of solar energy system in 1987

(Survey of Solar System Development Association)

Building types	System \ Year	1975~1984	1980~1984	1985	1986	1987	Sub total	Total
Single-family Houses	HW	3,756	215,913	37,848	30,310	20,734	308,561	309,643
	H & HW	342	601	34	18	6	1,001	
	H, C & HW	44	28	3	0	0	75	
	Other	4	2	0	0	0	6	
	Sub total	4,146	216,544	37,885	30,328	20,740	309,643	
Multi-family Houses	HW	26	336	36	15	36	449	465
	H & W		7	0	0	0	7	
	H, C & HW	4	3	0	0	0	7	
	Other		1	0	1	0	2	
	Sub total	30	347	36	16	36	465	
Commercial Buildings	HW	347	4,285	408	174	140	5,334	6,025
	H & HW	28	159	83	2	3	275	
	H, C & HW	75	250	8	4	3	340	
	Other	13	52	4	2	5	76	
	Sub total	413	4,746	503	182	151	6,025	
Indutsrial Buildings	HW	12	147	27	3	0	189	293
	H & HW	1	17	2	0	0	20	
	H, C & HW	2	14	0	0	0	16	
	Other	14	53	1	0	0	68	
	Sub total	29	231	30	3	0	293	
Sub total	HW	4,121	220,681	38,319	30,502	20,910	314,533	316,426
	H & HW	371	784	119	20	9	1,303	
	H, C & HW	125	295	11	4	3	438	
	Other	31	108	5	3	5	152	
Total		4,648	221,868	38,454	30,529	20,927	316,426	
(Public)	HW	82	1,384	210	68	53	1,797	2,183
	H & HW	15	46	81	1	1	144	
	H, C & HW	32	143	4	2	0	181	
	Other	7	48	2	0	4	61	
	Sub total	136	1,621	297	71	58	2,183	

HW:domestic hotwater supply, H:space heating, C:space cooling

Fig.5 Hamamatsu Press Tower in Hamamatsu with 190 units ($362\ m^2$) of the flat plate collector, storage of $12\ m^3$, absorption chiller of 40 refrigeration tons

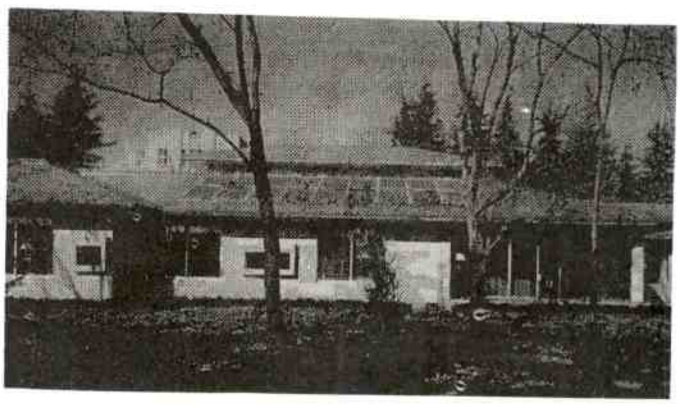

Fig.6 Loyola House for aged fathers in Nerima, Tokyo with a solar collector, 23 units ($89.2\ m^2$) of the flat plate type

systems and users' dissatisfaction with solar systems have decreased owing to accumulated experiences. From aesthetic viewpoint architectural design of solar houses and buildings has been refined as well owing to the fact that the first class architects have joined in the attempts in practice.

International competition for the building of Solar Energy Research Centerin Baghdad was a unique event and the team of Shimizu Corporation, the winner actually constructed the building including the solar heating and cooling systems [4]. A huge arrays of evacuated tubular collector mounted on the 45 degrees tilted south slope is really magnificent and it is reported that the system has been working quite satisfactorily with a slightly lower performance than expected. This can be evaluated as one of the few successful examples of solar cooling among many cases in the world. Most of the failed cases with solar cooling must be derived from unexpectedly greater heat losses from pipings and valves, collected solar energy being resulted in less contribution. It cannot be over emphasized to make the piping length as short as possible from collector to storage tank and from storage tank to absorption chiller [5][6].

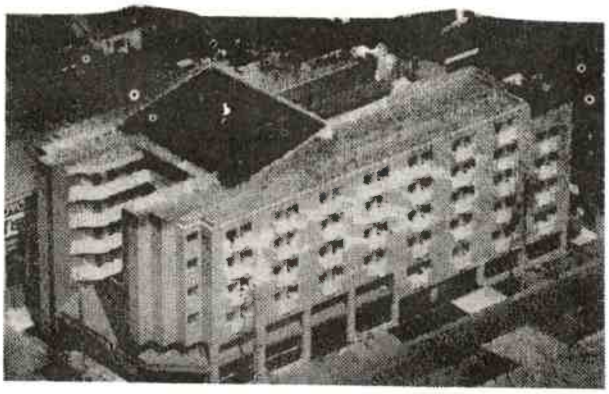

Fig.7 Fort Kitano in Hachioji, Tokyo with flat plate collector of 143 m^2 and storage tank of 7,500 litres

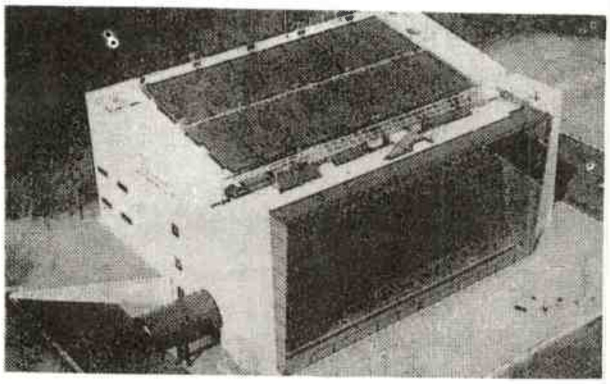

Fig.8 Ohbayashigumi Research Center in Kiyose with evacuate glass tube collector of 220 m^2 and absorption chiller of 10 RT

3.3 Economics of Solar Thermal Systems

Economical feasibility of solar thermal systems are often assessed by the number of years which the initial installation cost can be recovered by the annual savings associated with the amount of energy of solar contribution. If the interest rate is equal to the annual increase rate of the price of primary energy to be compared, oil for example, the recovery period of the initial investment can be expressed by the initial cost divided by the annual savings of the primary energy owing to solar contribution. Then afterwards the annual savings corresponding to the primary energy can be attained as long as the system works.

The recovery period can be longer than expected if oil prices get lower or the price increase rate may be smaller than the interest rate in future. It seems from the common sense that the recovery period of five years or less is regarded acceptable and the solar water heater is only one acceptable item of all solar systems at present. In fact people using solar water heaters are beginning to buy new ones to replace the previous ones with which they have satisfied.

As for the systems which would incur the recovery period of more than ten years economical feasibility greatly varies as to how the future price of control fuel be estimated. In general the amortization period of an article is determined by the expected life. In the case of the solar

systems, however, the life is longer than the recovery period and the annual savings by solar system will continue after the initial cost is paid back.

Still remains a question as to whether or not the price of depletable fossil fuel can be regarded appropriate as a control reference of economical feasibility for solar systems. Possible effects of pollution by burning fuels or danger of explosion and fire must be taken into account for attempting to draw true economical feasibility of solar systems.

Fig.9 Tonegawa's solar house in Kohnosu with a flat plate collector of 38 m^2 equipped with the storage tank of 760 litres

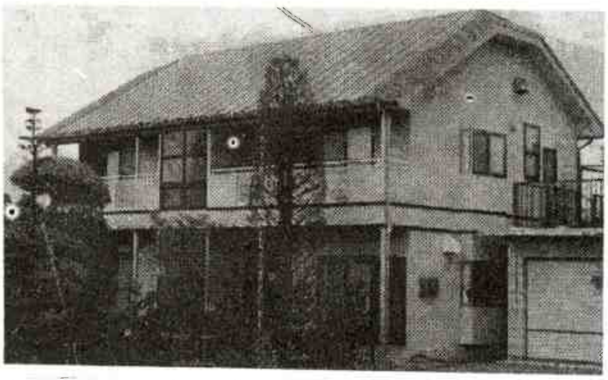

Fig.10 Kondo's solar house in Shiojiri, Nagoya with air type flat plate collector of 59.2 m^2

3.4 Government Subsidies for Solar Systems

Under the situations that solar systems must be promoted for the long run, Japanese Ministry of International Trade and Industry started the plan of subsidizing solar systems in 1980. Low interest loan for single family solar houses was set up at the interest rate of 5.5% to be returned in five years up to 2 million yens for installation cost of solar systems. More than 200,000 households utilized this loan in seven years and 99 % of them were providing solar domestic hot water supply system for not only bath tubs but also kitchen and laundry, thus contributing to the enhancement of living standard level to a certain extent.

The low interest loans for commercial application was also provided at the interest rate of 6.5 % to be returned in ten years. This was terminated after 7 years because of the shrinkage of governmental budget.

For public buildings, such as libraries, schools, old peoples' homes, etc., government subsidies are prepared up to one half of the initial total cost of the solar systems including auxiliary heat our. This is very effective and being welcome by many project leaders.

4. PASSIVE SOLAR HOUSES AND BUILDINGS

4.1 Passive Solar Heated Houses

It has been quite common to provide large south openings for the house in general and all of them in Japan may be called passive solar heated houses. Most of the apartment houses of concrete structure are being built in the same way to provide large south openings with balcony which functions as overhang for the premises below.

Modern wooden houses, however, have rather smaller thermal capacity than the traditional ones which used much clay walls with or without stucco

finish. Houses with light weight construction is being preferred in general today as they can be built within relatively short period of construction. Due to a lack in thermal capacity, they often can be over heated in the daytime of sunny winter days and resulted in excessive heat loss. Concrete floors are recommended for houses of wooden construction to make direct solar gain stored within.

Trombe walls are not so remarkably being applied in spite of a financial support made by Japanese Ministry of Construction. Low interest loan for the thermal storage concrete wall of 200 mm thick and more than 7 m² or equivalent is prepared. This can be considered quite effective in reducing energy consumption and in promoting interest in passive solar among general public.

However substantial reduction of heating energy has been realized principally by increased thermal insulation and air tightness of windows. Passive heating systems will work effectively in such buildings of minimal heat loss [11].

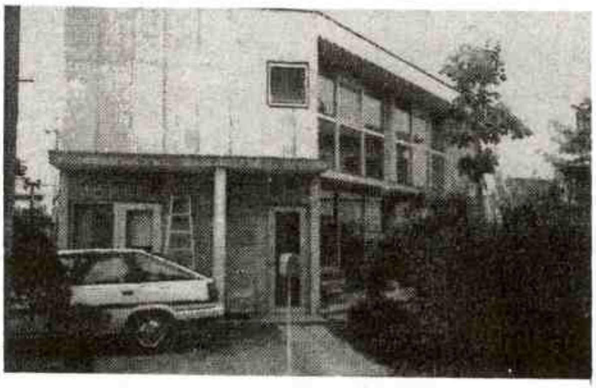

Fig.11 Matumoto Solar House, Sakado, Sitama designed by T.Iyama

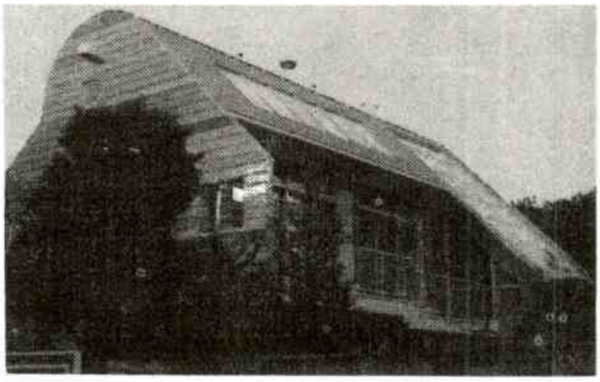

Fig.12 Miki Solar House, Setagaya, Tokyo designed by Y.Kato

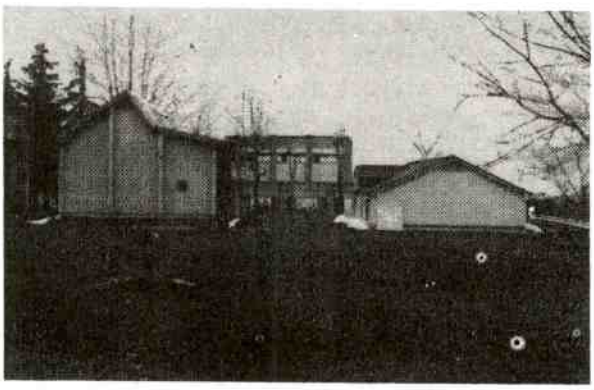

Fig.13 Two sets of Tandem Type of Passive Solar Houses of Tohoku Univ., Sendai

Fig.14 TEPCO All-electric Passive Solar Model House, Omori, Tokyo

4.2 Passive Cooling

On the other hand dehumidification is rather difficult and combined use of building materials with various degrees of porosity seems to give adequate characteristics. In fact the results of measurement in a traditional house with thick clay walls showed lower humidity ratio inside than outside by 1-2 g/kg in a hot summer day. Ceiling surface temperature was

also found lower than room air temperature which was likely to be caused by moisture desorption from the surface, though a big roof and void space above ceiling helped a lot to prevent overheating [10]. Whereas modern houses of light weight construction with non-porous materials and smaller roof structure are giving rise to high ceiling surface temperature nearly 40°C, thus requiring room air conditioners.

Earth sheltered buildings are not quite common in Japan, but some architects are attempting to design them. Evaporative cooling effect by earth cover containing moisture is so great that inside can be cool and comfortable under hot summer conditions, which was verified by field measurements [11].

Vegetation around buildings or balconies functions as sunshades and evaporative cooler to some extent. Cool air breeze can come into the house through plants where evaporative cooling takes place. Nocturnal radiation cooling is not so effective in Japan as in Mediterranean region because lots of moisture exit in the air even during the night.

In short complex use of various kinds of natural energy is necessary for the house to cope with severe summer conditions as there is no single powerful device of passive cooling.

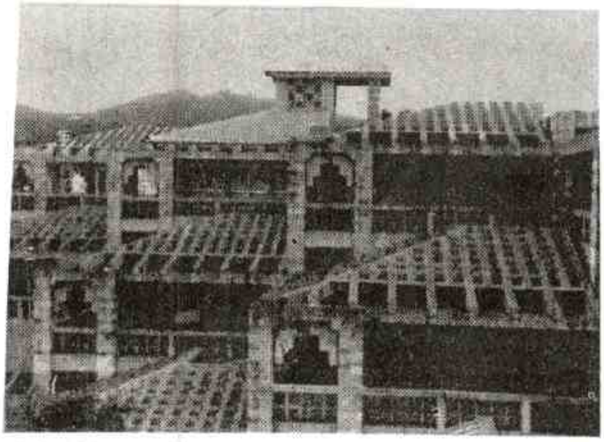

Fig.15 Nago City Hall, Okinawa designed by Team Zoo

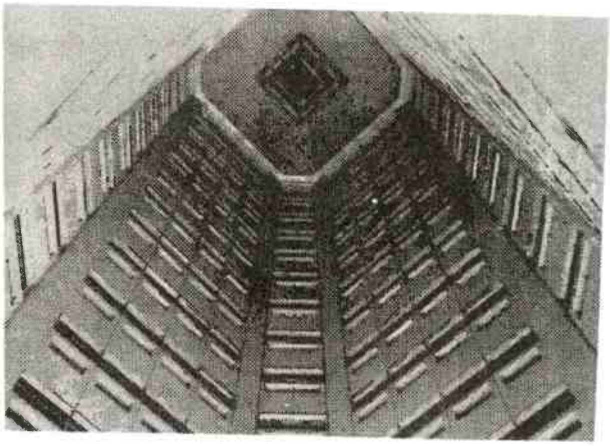

Fig.16 Deep Inner Court of Niigata Prefectural Office Building, Niigata to allow for natural ventilation designed by Nikken Architects, Planners and Engineers

Fig.17 Heavy clay wall storate type houses, Kawagoe, Saitama

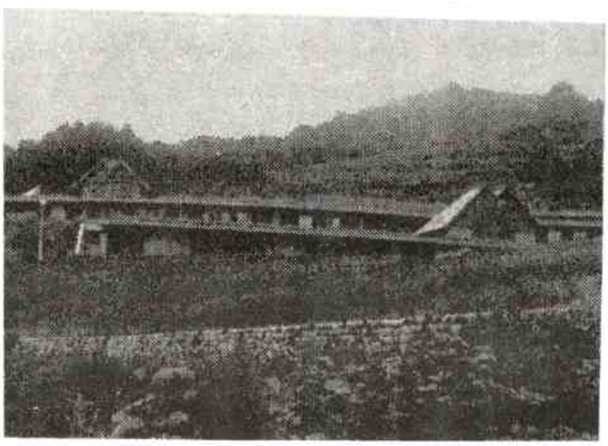

Fig.18 Earth sheltered summer resort bld., Nakano village, Gumma designed by Sakakura Architects

4.3 Nature Oriented Architecture and Healthy Indoor Environment - Conclusive Remarks

Without mechanical air conditioning, we can work in light clothing under the indoor temperature of 29°C with slight breeze and if dehumidification can be realized by passive means, room air temperature up to 31°C may be accepted [12]. Allowing for room air temperature swing, occasional slight discomfort might be accepted and temporary breeze would stimulate occupants comfortably. Thus passive cooling may be achieved imperfect cooling with very low energy consumption.

As for air conditioning, unpredictable hazard like overcooling disease around feet or indoor air pollution on account of poor ventilation has been sometimes apparent today. High technologies are makeing it possible tc realize optimum air conditioning for occupants who work with machines or mechanized occupants in modern intelligent buildings. Neverthless the air supplied through mechanical systems, no matter how perfectly it might be conditioned in terms of temperature and humidity, could not be compared with the air in nature. Human beings tend to dislike technologies and love nature, though we are owing the technolgies a lot.

Now that the natural green is more precious than the buildings in modern cities, passive cooling idea may be graded higher than air conditioning based on technological logic. On the other hand passive cooling is also dependent on technical means and such technologies as offering us cool sensation must be developed in the years to come.

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DEVELOPMENT OF COMMUNITY SIZED SOLAR POWERED COLD STORAGE IN LIBYA.

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ABSTRACT:

Average solar radiations in Libya vary from 2.0 $KW.hr/m^2$. day to 7.35 $KW.hr/m^2$. day and the average wind velocity varies from 2.78 m/s to 6.59 m/s. A system has been discussed which integrates solar and wind energies, and stores it, round the clock, to run a small cold storage. Direct and diffuse solar radiations as well as those reflected from huge reflectors are allowed to fall over a solar pond. An electric generator coupled with a wind turbine shaft generates electricity, which is fed to an immersion heater put in the lower convective zone of the solar pond allowing the fluctuating wind energy to be converted and stored in the form of heat energy. The stored energy can be utilized by the generator of a vapour absorption system of a cold storage.

1.INTRODUCTION:

Average direct solar radiations at most of the areas in Libyan Arab Jamahiriya vary from 2.0 $KW.hr/m^2$.day to as high as 8.0 $Kw.hr/m^2$.day, average diffuse solar radiations vary from 1.0 $KW.hr/m^2$.day to 2.5 $Kw.hr/m^2$.day and average wind speed varies from 2.80 m/s to 6.60 m/s. These two renewable and clean sources of energy have, therefore, a good potential if these are harnessed judiciously. Centre for solar energy studies in Tripoli has published sufficient data regarding solar radiations and wind speeds for some of major areas in the Jamahiriya (1,2). Some solar radiation data in table 1 and wind energy data in table 2 are quoted here to show the prospects of this energy in Jamahiriya. These data can be used to develop and design integrated systems to supply energy requirements of a small community sized cold storage.

A survey of the population pattern shows that the community sized cold storages would be suitable in Libya. Agriculture, fisheries, dairy and poultry products are increasing every year. Installation of small cold storage in each farm will minimise the spoilage of the product. A survey of the solar and wind energy data shows that the average solar radiation is at its minimum during winter season when the average wind speed is at its maximum. Similarly, during summer season the average solar radiation is at its peak when the average wind speed is the lowest. Of the late solar energy has got wide applications (3,4) in heating and coolding of space. Wind energy is also found to posses a good potential for providing energy required for low capacity systems (5,2). Both solar and wind energies are intermittent in nature and any system which utilizes these two non-conventional sources of energy must have provision for storage of energy. A solar pond will be best suited for this purpose. It is a shallow body of water containing dissolved salt which have a stable density gradient from lowest at the surface to highest at the bottom (6).

TABLE (1) : MEAN MONTHLY SOLAR ENERGY AVAILABILITY IN 10 IMPORTANT LOCATIONS IN LIBYA KILOWATT-HOURS ON A HORIZONTAL SURFACE (9).

Location	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average	Watts Continuous basis
Zuarah $11^{\circ}15'$ $37^{\circ}21'$N	4.50	5.22	5.74	6.02	6.27	6.43	7.05	6.89	6.12	5.60	4.97	4.36	5.76	240
Tripoli 13° 7'E $36^{\circ}41'$N	4.70	5.45	6.12	6.71	7.21	7.52	8.00	7.81	6.81	6.00	5.18	4.60	6.35	265
Misurata $15^{\circ}12'$ $34^{\circ}15'$N	4.57	5.45	5.98	6.51	6.82	6.89	7.54	7.45	6.56	5.80	5.09	4.47	6.02	251
Sirte $16^{\circ}35'$E $31^{\circ}12'$N	4.72	5.55	6.35	6.62	6.56	7.29	7.49	7.50	6.74	5.96	5.26	4.81	6.24	260
Ejdabiya $20^{\circ}11'$E $30^{\circ}43'$N	4.78	5.71	6.36	6.92	6.37	7.73	7.78	7.72	7.07	6.40	5.42	4.68	6.50	271
Benina $20^{\circ}51$E $31^{\circ}15'$N	4.47	5.24	6.01	6.67	7.30	7.51	7.77	7.70	6.91	6.08	5.14	3.17	6.16	257
Shahat $21^{\circ}50'$E $32^{\circ}50'$N	4.12	4.88	5.58	6.27	7.02	7.51	7.48	7.28	6.42	5.56	4.80	4.14	5.92	247
Dernah $23^{\circ}15'$E $33^{\circ}15'$N	4.21	5.05	5.59	6.08	6.48	6.74	6.71	6.73	6.26	5.57	4.79	4.18	5.70	238
Tubrug $24^{\circ}00'$E $31^{\circ}51'$N	4.69	5.54	6.11	6.63	7.08	7.30	7.70	7.47	6.84	6.03	5.22	4.64	6.27	261
Elgagbub $20^{\circ}30'$E $32^{\circ}14'$N	4.86	5.57	6.09	6.67	7.72	8.84	8.94	8.70	7.89	6.39	5.52	4.55	6.58	283

TABLE (2): MEAN MONTHLY WIND SPEED IN KNOTS

SYNOPTIC STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR	NO.OF YEARS	PERIOD
NALUT	10.0	9.9	10.7	11.2	10.3	11.3	9.0	8.9	9.2	8.5	8.3	10.3	9.8	29	1949-77
ZUARA	6.8	7.0	8.3	9.0	7.9	8.0	6.7	6.9	7.5	6.6	5.8	6.4	7.2	29	1949-77
TRIPOLI A/P	7.2	7.0	7.6	8.4	8.1	8.4	7.0	7.1	7.4	6.6	6.2	7.1	7.3	29	1949-77
MISURATA	6.7	6.5	8.3	8.1	6.9	6.6	5.1	4.6	5.2	4.9	4.9	6.3	6.2	29	1949-77
SIRTE	8.1	8.2	9.0	9.0	8.0	7.2	6.4	6.3	6.7	7.4	7.4	8.1	7.7	32	1946-77
BENINA	9.2	9.7	10.3	11.4	10.5	10.6	10.8	10.2	9.2	9.5	9.2	9.4	10.0	29	1949-77
AGEDABIA	4.9	5.4	6.6	7.2	6.4	6.0	5.7	5.4	4.8	4.9	4.3	4.7	5.5	29	1949-77
SHAHAT	13.3	13.2	13.0	12.1	9.0	10.6	6.2	6.1	6.5	9.2	11.5	14.2	10.4	29	1949-77
DERNA	13.0	13.0	13.5	12.9	10.9	12.1	15.6	15.2	12.4	10.2	11.3	13.2	12.8	29	1949-77
NASHER A/P	10.2	10.9	11.6	12.0	10.8	11.4	12.5	11.6	9.2	8.8	8.7	10.2	10.7	24	1954-77
GHADAMES	8.1	8.5	10.2	11.5	10.9	10.8	9.6	8.8	9.1	8.4	7.2	7.9	9.3	16	1962-77
GHARIAN	7.8	8.8	10.2	9.6	8.5	8.8	6.5	6.9	6.7	6.6	6.7	6.7	7.8	10	1968-77
SEBHA	7.3	8.4	10.8	11.5	11.5	11.1	10.0	9.6	9.9	9.2	8.3	7.4	9.6	16	1962-77
HON	6.9	7.4	8.7	9.5	9.1	8.4	7.0	6.8	6.9	6.8	6.2	6.8	7.5	29	1949-77
JALO	6.1	6.4	7.8	8.5	7.2	6.9	7.2	6.7	5.6	5.2	4.8	6.1	6.5	28	1950-77
GIARABUB	5.9	6.4	7.5	8.1	7.7	7.9	8.0	7.4	6.1	5.7	4.7	5.2	6.7	28	1950-77
TAZERBO	4.6	5.5	6.5	6.9	6.4	5.9	5.5	5.1	4.7	4.8	4.2	4.4	5.4	16	1962-77
KUFRA	5.2	5.9	6.9	7.7	7.7	7.6	7.5	7.3	7.0	6.3	5.2	5.1	6.6	29	1949-77

In the present paper, a system has been proposed in which direct, diffused and reflected solar radiations fall on a solar pond surface. Wind energy is harnessed with the help of a wind turbine, the shaft of which is connected with an electric generator. The generated electricity is given as input to an immersion heater put in the lower convective zone or the storage zone of the solar pond. The stored heat energy will be used by the generator of a vapour absorption refrigeration system of the proposed cold storage.

2. PROPOSED SYSTEM:

A shallow 3 meter deep solar pond is proposed as shown in Fig.(1). It contains 3 m deep water with dissolved salts to generate a stable density gradient. Direct, diffused and reflected solar radiations fall on the pond surface and these are stored in the form of heat energy mainly in the lower convective zone having a uniform high concentration salt. The reflector may be fabricated by using small plane glass mirrors. The whole mirror frame can be moved or/and tilted in any position so as to concentrate the reflected beam of sun light on the pond surface. An electric generator is coupled to the vertical shaft of a wind turbine. The generated electricity is fed to a resistance heater, immersed into the lower convective zone of the pond. The solar and wind energies will suppliment each other and their reasonal distribution pattern will enable an almost uniform solar pond temperature.

It has been reported in the literature (7) that for the same conditions a water lithium bromide system is simpler and more efficient compared to the ammonia-water system. It is also possible to have a pumpless water lithium bromide system. The main disadvantage of the system is the limitation of lower temperature which is about 2°C. Due to this limitation a water lithium bromide system, shown schematically in Fig. (3), must be used for cold storages of fruits and vegetables which are cold preserved unfrozen. For fishery, dairy and poultry products, which are preserved in frozen state, the ammonia water system of Fig. (2) must be used.

3. REFRIGERATION SYSTEM ANALYSIS:

The cooling ratio of a vapour absorption system is defined as the ratio of the energy removed by the evaporator to the energy supplied to the generator. It increases as the condenser and absorber temperatures decrease. The most important parameter is the generator temperature as all the other parameters are almost fixed, being function of existing initial conditions. The cooling ratio increases with an increase in the generator temperature. For the ammonia water and water-lithium bromide cycles of Figs. (2) and (3) respectively, the cooling ratio is defined at (7):

$$CR = \frac{h_{fg}}{\frac{1}{yr}(h_v - h_w) + hw + (R-1)h_1 - R.h} \qquad (1)$$

$$CR = \frac{h_{fg}}{h + (R-1)\,h_4 - R\,h_3} \qquad (2)$$

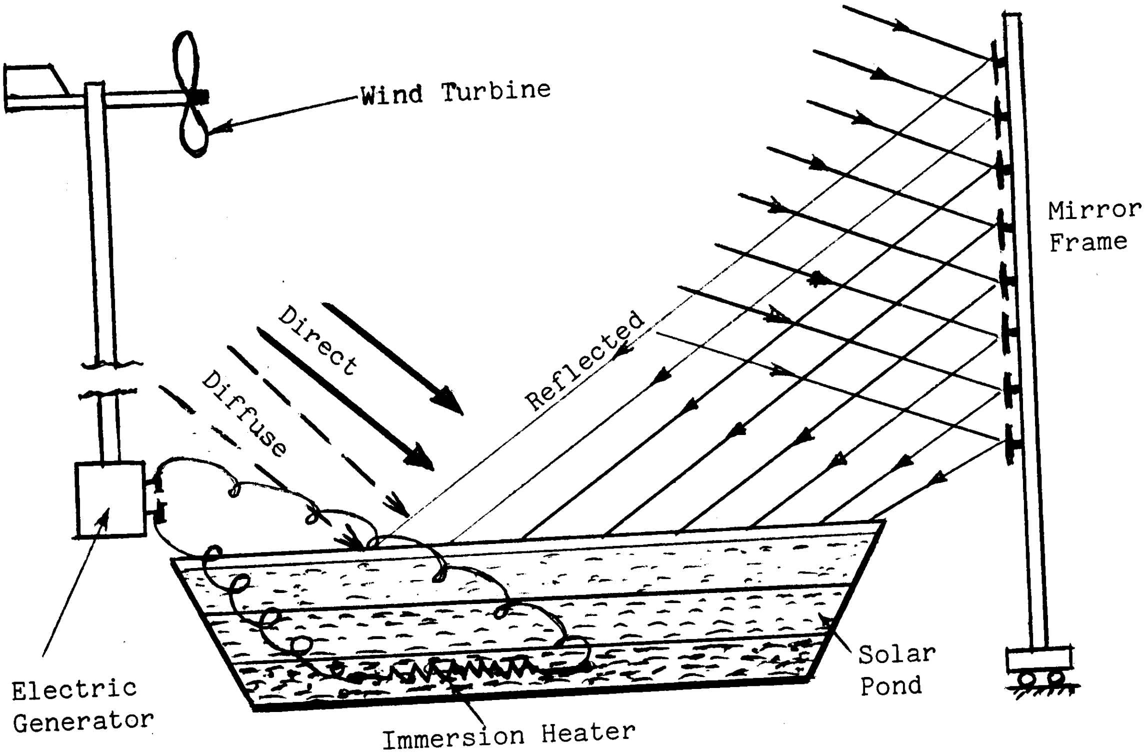

Fig. 1 Schematic of Energy Storage System

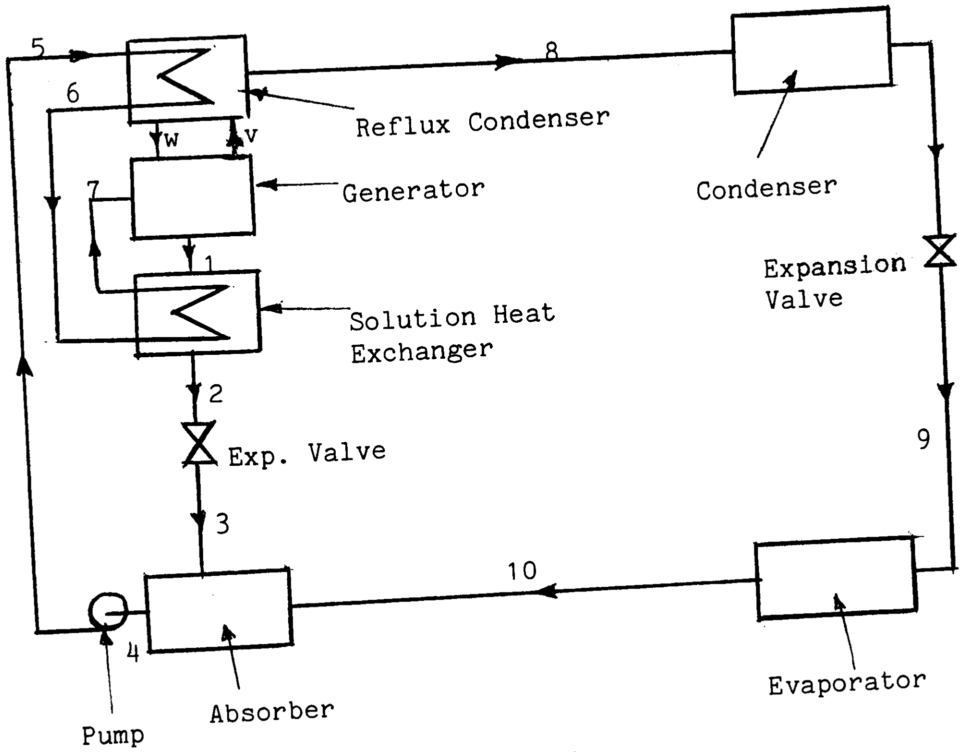

Fig. 2 Schematic of Ammonia-water System

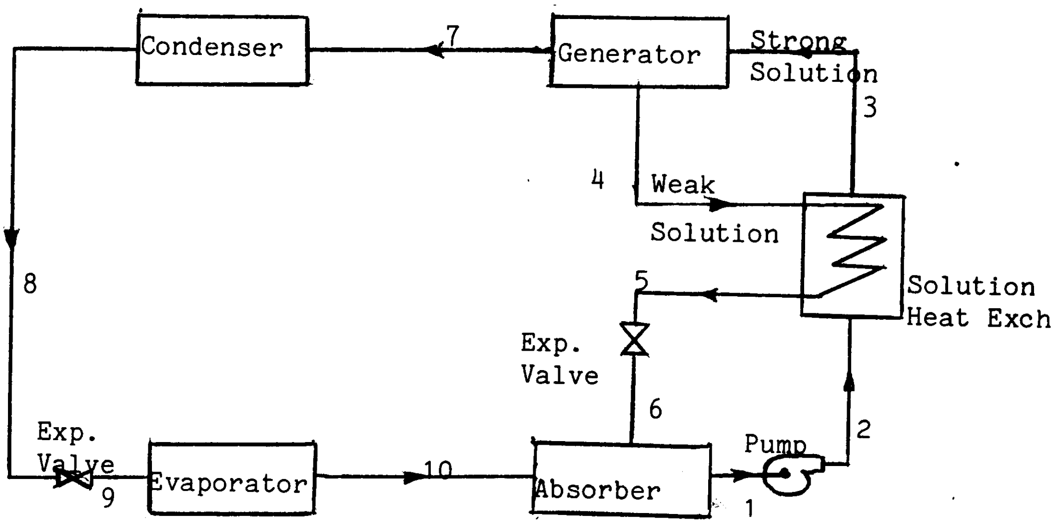

Fig. 3 Schematic of Water-lithium bromide System

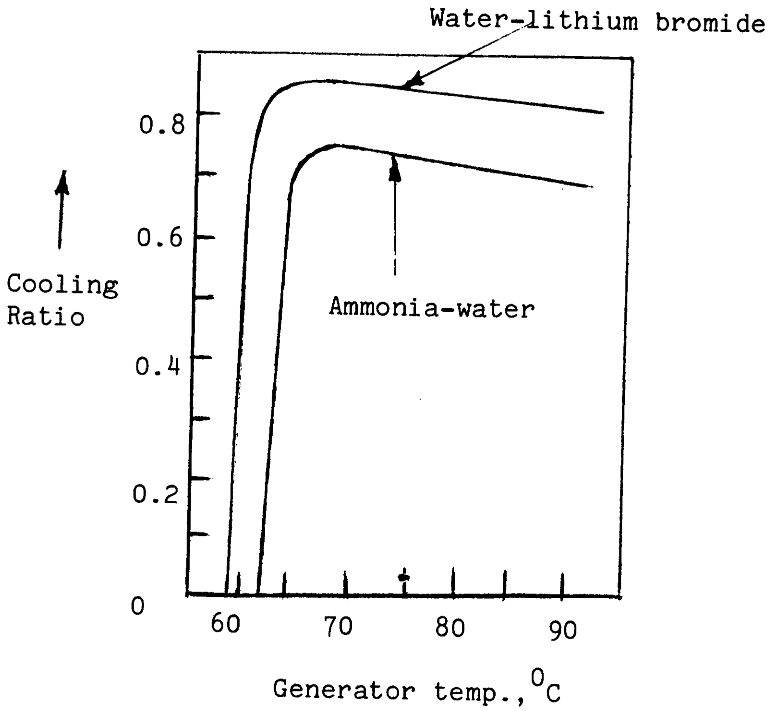

Fig. 4 Cooling Ratio versus Generator Temperature

Where

R is the circulation factor defined as

$$R = \frac{Yr - Ya}{Ys - Ya} \tag{3}$$

h_{fg} is the enthalpy of vapourization, KJ/Kg

Yr is lithium bromide or ammonia weight, per cent, in the refrigerant vapour leaving the generator.

Ya is the weight concentration of weak solution (weak in refrigerant) leaving the generator

Ys is the weight concentration of strong solution leaving the absorber.

h_v is enthalpy of water vapour, KJ/Kg.

h_w is enthalpy of saturated water, KJ/Kg.

The subscripts of enthalpies are in accordance with Figs. 2 and 3 respectively.

A detailed theoretical investigation has been carried out by different investigators (7, 8) regarding the design and optimization of water-lithium bromide and ammonia-water absorption refrigeration cycles. It has been shown that in general for fixed initial conditions and given refrigeration capacity higher generator temperature causes higher cooling ratio and results into lower cost. It has also been reported that water-lithium bromide system operates at a higher cooling ratio and smaller heat exchange surfaces for the same conditions.

4. DISCUSSION:

The hot brine solution from the solar pond will be passed through the generator of the vapour absorption systems. The cooling ratio of a system, for a given set of absorber, evaporator and condenser temperatures, is found to be a strong function of generator temperature. One typical curve each for water-lithium bromide and ammonia-water system is shown in Fig. 4 (7). It is found that there is an optimum generator temperature for which the cooling ratio is maximum. A thorough experimental and theoretical investigation is essential for the development of a cold-storage run on the solar and wind energies. During the summer season only solar energy may be sufficient for the vapour absorption systems. During winter, the cooling load of the cold storage falls down and only a solar system may seem to be justified. But during cloudy winter periods the system may not work at all. Incidentally during this period the vegetable and fruit production is very high. For the cold storages meant for these products there will be sufficient product and respiration heat to necessitate a continuous refrigration. Fortunately during such periods the wind speed is maximum and the wind system will meet the energy needs of the absorption system.

The temperature of the cold storage must be decided according to the commodity to be stored. The installation of such small cold storages on the production site will minimize the food spoilage. Such cold storages may be used as part of existing units for precooling purpose or as independent units for short term storage before transferring the commodities to the central storages for long term preservation. The heat energy of the solar

pond may also be used for heating or cooling of the farm-houses and nearby poultry or cattle farms.

5. CONCLUSION:

The solar and wind energy data and population pattern of Libyan towns make it an ideal place for developing small community sized cold-storages which get their energy supply from an integrated system using solar and wind energies. A water lithium bromide system is more suitable for situations in which the temperature of the refrigerated space is around $2^{o}C$. For lower or freezing temperatures an ammonia-water system will be more realistic.

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COMPARATIVE STUDY FOR TWO AIR SOLAR COLLECTORS

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ABSTRACT :

Among all configurations of air solar collectors, two of them were chosen to be tested.
The objectives were to make collectors as simple and cheap as possible and as efficient as possible so they can be used in any situation for agricultural products drying, or building heating at a low cost. The configurations chosen were :

1 - Simple flow, i.e. flowbetween the absorber and the glass cover,
2 - double flow, i.e. flow between the absorber and the glass cover and flow between the absorber and the back isolation with a mixing at the exit of the collector.

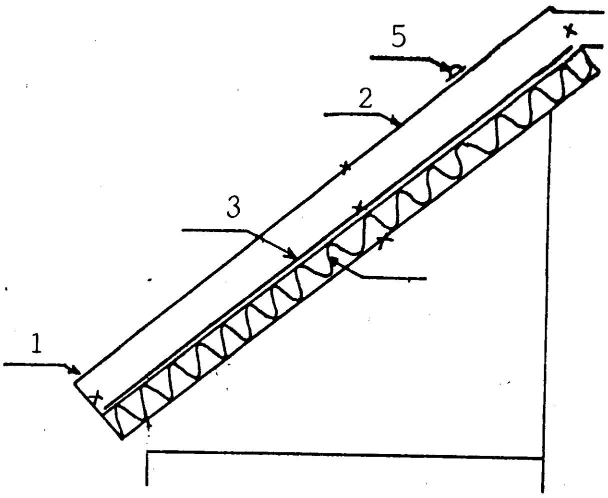
1. INTRODUCTION :

Solar collectors with air as the heat removing fluid have been used in many applications such as drying (Crops, construction materials,..), space heating, etc..Different types were built with different absorbing materials, iron or aluminum plate, painted black or coated with a selective surface, single or double glazing or even more, with different insultation materials (glass fibre, polyurethan, polystyren, etc..). However using more efficient materials means more investment in materials.

In this work, we present a study done on two types of collectors made of material Commonly found on the market, relatively inexpensive. The theory is not repeated here since many anthors have gone through. The report stresses mainly on the results of the experimental study. All the tests were performed in open circuit.

2. EXPERIMENTAL APPARUTUS :

The work presented here discusses two configurations of the air heater. These air heaters are made of the same materials. They differ from each other in the positionning of the absorber. The solar radiation is absorberd by an aluminum plate which is painted in black ($\alpha = 0.96$). The cover is a 0.04 m thick glass and the back side is made of polyurethan foam insulation covered with a wooden sheet of 5 mm thickness. All mounted in a wooden frame. In one type, fig.1, the air flows between the glass cover and the absorber plate and the other type, fig.2, the air flow is "Split" at the entrance, flowing partly between the absorber plate and the glass cover,partly between the absorber plate and the back insulation.



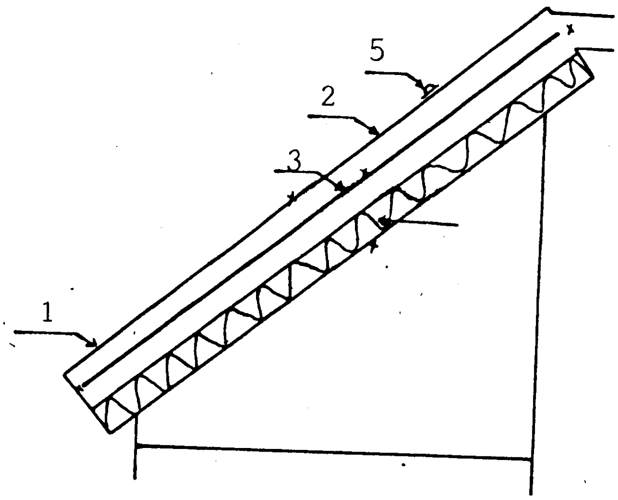


Fig.1. One channel collector. Configuration two.

Fig.2. Two channel collector configuration one.

1,Solar collectors; 2,Glass cover; 3,Aluminum absorber plate; 4,Polyurethan insulation ; 5, Pyranometer; X, Thermocouples.

The aperture area of the collector was 1.920m X 0.86m and the flow rate was 0.0259 Kg/s and maintained constant throughout the experiment.

The inlet and outlet air temperatures, absorber plate, glass cover temperatures, back side temperatureswere measured with iron - constantan thermocouples connected to a philips recorder. The solar intensity was recorded using an Eppley pyranometer positionned at the same slope as the collector.

All tests were carried out outdoor at the Centre de Developpement des Energies Renouvelables. (Renewable Energy Center) Bouzareah Algiers. The collectors were set at on inclination of 45° facing due south. Ambiant temperature and ambiant wind speed were taken from a meteorological station

near by.

3. RESULTS AND CONCLUSION :

In the theoritical study, it was clear that the flow was turbulent. The velocity was maintained constant by a wind rotary vane. A simple analysis shows that, in steady state, the efficiency of the collectors is given by :

$$\eta = \frac{m.c\ (T_{fo} - T_{fi})}{A_c \cdot Q_s}$$

The behavior of the collectors is represented by some results shown in the figures. All parameters pertaining to the collectors are shown as functions of the solar intensity.

The outlet air temperature for configuration one is higher than the one for configuration two for solar intensity up to 700 W/m^2 fig. 3

The absorber plate temperature follows the same evolution as the outlet air temperature fig. 4

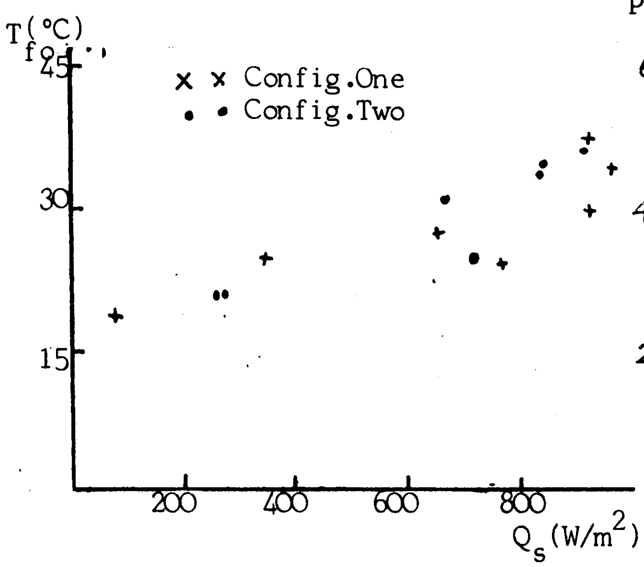


Fig.3 Outled air temperature as a function of solar intensity.

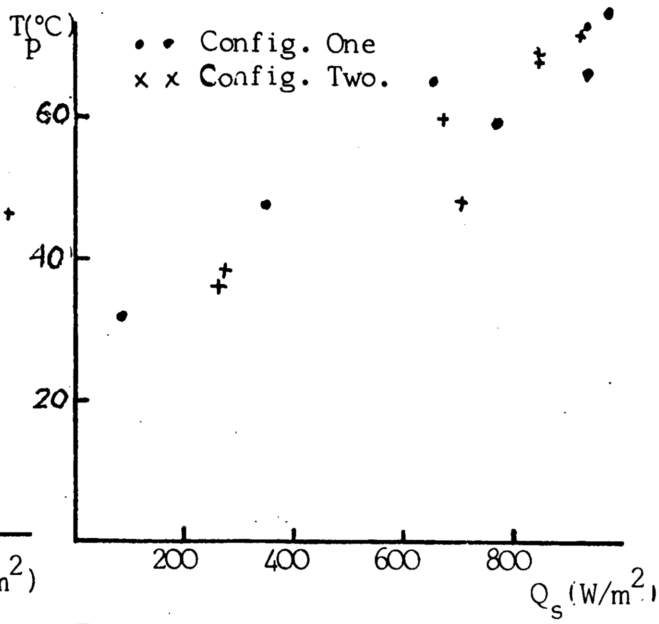


Fig.4 Absorber plate temperature versus solar intensity.

The glass cover temperature changes slightly with the solar intensity for configuration one, but for configuration two, this temperature seems to increase fig. 5. In fig. 6 we have the back side temperature for both configurations. Configuration one presents a temperature varying slightly with solar intensity ; on the other hand configuration two has an increasing back side temperature.

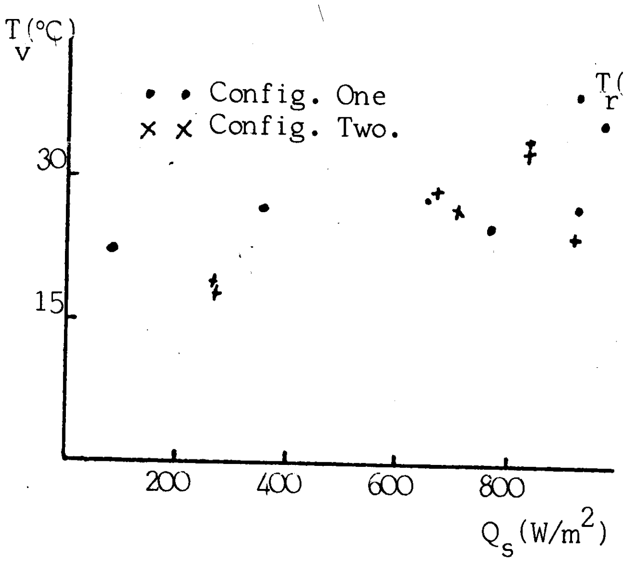


Fig.5 Glass cover temperature versus solar intensity.

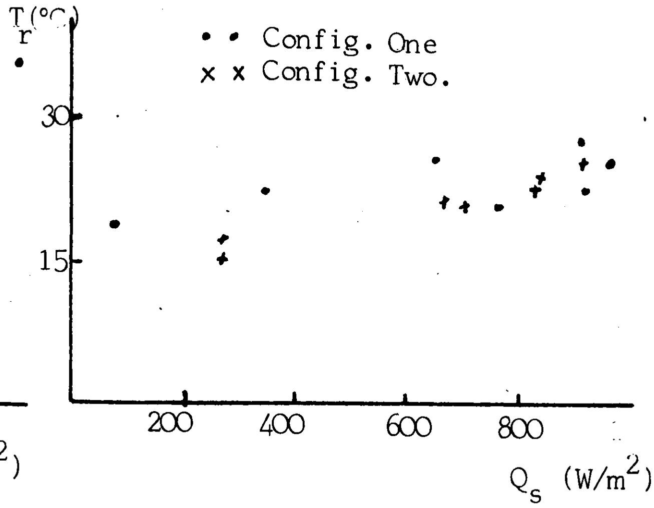


Fig.6 back side temperature versus solar intensity.

In fig. 7, the efficiencies are represented for both configurations From the observations, it may be concluded that the two channel flat plate collector presents a better efficiency. Considering Ref.[4] and increasing slightly the space between the absorber plate and the glass cover might improve the efficiencies, specially the two channel collector. Elsewhere, considering Ref.[5] , increasing the length of the collector might increase the outlet air temperatures and improve the efficiencies.

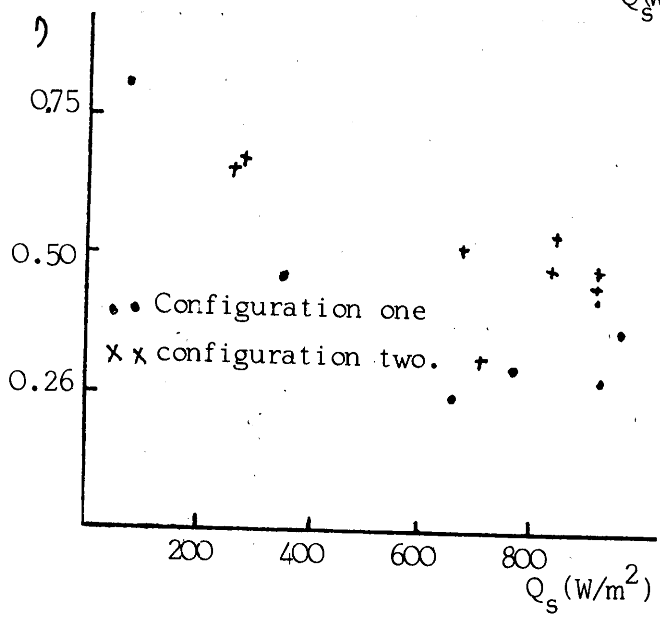


Fig.7. Efficiencies for both configurations.

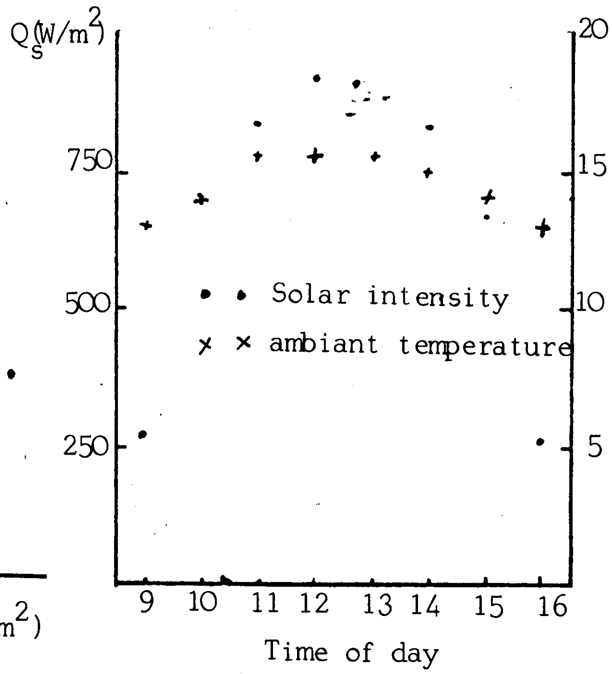


Fig.8. Solar intensity and ambiant temperature

The choice for one of the two configurations depends on the purpose to be reached, good efficiency or high outlet air temperature. It is important to recall that the improvement in efficiency of the two channel configuration is gotten with the same material and little additional construction cost because the main difference between the two configurations resides in the positioning of the absorber plate.

NOMENCLATURE :

A_c	Absorber plate area, m^2
$\dot{m}$	air mass flow rate, kg/s
T_{fi}, T_{fo}, T_a	air température at the inlet section, outlet section and the ambiant, respectively, °C
T_u, T_b, T_r	Glass cover, absorber, back side temperatures, respectively °C
Q_s	Incident solar intensity, W/m^2
η	Collector efficiency i.e ratio between the power input to the air in the collector and the incident power.

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رفع كفاءة الخلايا الشمسية بواسطة جهاز تتبع مسار الشمس

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ملخص :
تمثل الطاقة بمختلف أنواعها أحد الأمور التي تشغل فكر الانسان على مختلف العصور وتجعله يعمل على تسخير الطبيعه في الاستفاده من المصادر المتاحة ، وحيث ان الشمس هي مصدر جميع الطاقات ، عمل الانسان على استغلالها منذ القدم في عمليات التجفيف والتسخين وبعض الأغراض الأخرى . وللحاجه الملحه في توفير الطاقه اللازمه للحياه خصوصا مع التقدم الذي يشهده العصر الحالي ولتناقص بعض الموارد المتاحه مثل النفط والفحم والقيود التي تواجه استعمال الذره في توفير الطاقه اللازمه مع التزايد الهائل للسكان ، أخذ الباحثون في مجال الطاقه على عاتقهم العمل لايجاد الوسائل التي من شأنها استغلال المصادر الطبيعيه والتي تحتل الطاقه الشمسيه النصيب الأكبر منها ، في توفير الطاقه اللازمه ، وبالفعل تمت الاستفاده من هذا المصدر في مختلف المجالات مثل التدفئه وتسخين المياه والتحليه وكذلك الحصول على الطاقه الكهربائيه ، وتفيد الدراسات في هذا المجال بأنه من الممكن الحصول على قدره كهربائيه حوالي واحد كيلوواط لكل متر مربع معرض للشمس في صورة خليه شمسيه . ومن هذا المنطلق بدأ التفكير في كيفية رفع كفاءة الخلايا الشمسيه وتم التوصل الى فكرة تكوين جهاز يعمل على رصد حركة الشمس وتحديد زاوية ميل أشعة الشمس على سطح الأرض في مكان معين وتحريك المستوى الحامل للخلايا الشمسيه بحركه تتناسب مع حركة الشمس وفيها تكون أشعة الشمس في وضع متعامد على مستوى الخلايا الشمسيه في معظم ساعات النهار ، وبهذا الجهاز يتم رفع كفاءة الخلايا الشمسية من ٣٥ الى ٤٤ % .

وفي هذه الورقه نتعرض لدراسة تفصيلية لمكونات جهاز تتبع مسار الشمس والتحسينات التي أجريت عليه ، وقدرته التخزينيه والمشاكل التي حدثت أثناء اجراء التجارب عليه وكيفية التغلب عليها بالاضافة الى الاعتبارات الاقتصاديه للجهاز ونطاق استعمالاته كجهاز للرصد .

١-مقدمة :

تقدم الطاقه الشمسيه بديلا مناسبا من بدائل مصادر الطاقه في حالة امكانية التغلب على المشاكل التي لازالت تواجه الاستغلال الاقتصادى الأمثل لها • وذلك لوفرتها في البلاد التي تتمتع بسطوع شمسي عال ولضآلة كل من تكاليف التشغيل والتأثير على البيئه المجاوره • وتبقى الى جانب النواحي الاقتصاديه المتمثله أساسا في الارتفاع النسبي للاستثمارات اللازمه لتوليد الكهرباء بالطاقه الشمسيه ، تبقى بعض الجوانب الفنيه التي يتحتم معالجتها للوصول الى الهدف •

واستخدام الخلايا الكهروضوئيه لتوليد الطاقه الكهربائية من الطاقه الشمسيه هي احد أهم طريقتين رئيسيتين للحصول على الكهرباء من طاقة الشمس ولعلها الاكثر انتشارا • ان ارتفاع الكلفه الابتدائية للوحات هذه الخلايا تدعو الى الاستفاده المثلى من هذه اللوحات برفع كفاءة استغلالها الى الحد الاقصى الممكن • وقد لوحظ ان الشعاع الشمسي يعطي أكبر فاعليه له في انتاج الطاقه الكهربائيه عندما يكون متعامدا على مستوى لوحة الخلايا • ونظرا لحركة الأرض المستمره بالنسبه للشمس طوال فترة النهار بدت فكرة تتبع مسار الشمس بالنسبه للارض بما يحافظ على الوضع المتعامد للاشعه الشمسيه على لوحات الخلايا •

٢-تتبع مسار الشمس :

ويقصد بذلك الحفاظ على الوضع المتعامد المذكور خلال ساعات السطوع الشمسي ، ومع ملاحظة أن موضع الشمس الظاهر يتغير بمرور النهار بمقدار زاوية معينه واحده لكل وحده زمنيه معينه فان هذه الزاويه تتوقف على الفصل الزمني السنوى ويعتمد عليها اقامة ونصب مستقبل الطاقه الشمسية • وهذا يتطلب تقنيه مناسبة ويواجه مشاكل أساسيه تمت دراستها ومحاولة التغلب عليها في تقديم جهاز تتبع مسار الشمس الآتي تفصيله ، وتتمثل أغلب هذه المشاكل في ضمان الحركه الذاتيه للمستقبلات بحيث تحافظ على وضع التعامد وبالتالي معرفة وتوفير كافة المحاور اللازمه للحركه • كما ان اختيار المواد اللازمه التي تعطي خدمات جيده مناسبة لفترات طويله ولا ترهق التكاليف الاساسيه للجهاز مشكلة أخرى ذات أهمية •

هذا الى جانب ضرورة أن يكون التصميم للجهاز بحيث يعطي اعتماديه ومرونه تشغيل مناسبتين تراعي امكانية استغلاله في مناطق نائيه ولفترة طويله وتحت ظروف جويه قد تكون قاسيه •

٣-جهاز تتبع مسار الشمس (٤) :

يعطي هذا الجهاز الذي تم تصميمه وتنفيذه ليوفر امكانيات ومزايا عديده في هذا المجال وادخلت عليه العديد من التحسينات والاضافات أثناء فترة تجربته الحقليه يعطي أداء جيدا بكفاءة عاليه •

ويتكون الجهاز الاشكال (١ ، ٢ ، ٣) من اداة لتوجيه مستقبل الطاقه الشمسيه (المجمعات الكهروضوئيه) تحدد موضعه وحركته تبعا لحركة الشمس بالنسبة للأرض ويتميز بوجود هيكل انشائي قائم بذاته ، جزء منه دوار ومثبت عليه اطار لتركيب المستقبل الشمسي ، ويحوى اداة ادارة مرتبطه بالجزء الدوار ،

ووسيلة تحكم تقوم بتوجيه اداة الادارة بواسطة مستشعر واحد على الاقل حساس لضوء الشمس مركب على الجزء الدوار من الهيكل الانشائي .

ويتميز الهيكل الانشائي على وجه الخصوص بوجود قاعدة ارتكاز عليها محور ارتكاز مستند عليه محور ارتكاز آخر ، كما يوجد صاري عمودي على المحور الأوسط قابل للدوران ومرتكز على كرسي ارتكاز المحاور بطريقة تسمح بوجود اطار المستقبل الشمسي على الجزء الحر الحركه للصاري بحيث يمكن حركته حول المحور الافقي .

وتتم الحركه عن طريق نضيدتين تغذى الأولى مجموعة الحركه بطاقة التشغيل اللازمه لها بينما تغذى الثانيه وحدات الاستهلاك الأخرى بالطاقه الكهربائيه وتوفر طاقة الشمس اللازمه للنضيده الاولى وتستغل الطاقه الشمسيه التى يوفرها الجهاز فى شحن النضيده الاولى . وتعمل النضيده على توفير الطاقه اللازمه كذلك لارجاع الصارى أثناء الليل ليعود الى وضع الابتداء من جديد فى بداية النهار التالى .

ويسمح الجهاز بالحركه حول كل من المحاور الافقيه والمحاور الرأسيه لتمكين مستقبل الطاقه الشمسيه من مواجهة الاشعه الساقطه بشكل متعامد .

ويحوى الجهاز حامل رئيسى للمجموعه مزود بقاعده تحميل افقيه وكرسى تحميل أول يتبعه كرسى تحميل ثان يستند عليه ويعد الكرسى الأول كرسى انزلاق محورى له قلب انزلاق من مادة منخفضة الصلابه نسبيا لتقليل مقاومة الاحتكاك ، أما الكرسى الثانى فهو اسطوانى قطرى .

ومثبت بالكرسيين صارى طولى رأس يستخدم كمحور دائرى يدار طوليا عن طريق الكراسى المذكوره . وقد صممت أغطية كراسى الدوران بطريقة خاصة لمنع وصول أى من الرواسب والأتربه وما اليها داخلها . وجعلت النهاية العليا للصارى حرة بزاوية دوران مقدارها ٢٤٠ درجه طوال النهار وهى أقل من الممكن اتخاذه وذلك لتسهيل تمرير حركة الكوابل الكهربائية من تحته .

وتوجد مجموعتان للحركه لكل منهما محرك كهربائى يتغذى من الجهاز ويمكن أن تعمل أى من المجموعتين بالتيار المستمر . تختص المجموعة الأولى بادارة الصارى بينما توفر الثانية حركة الانكفاء والميل للاطار الحامل للمستقبلات . وقد صنعت التروس والتعاشيق من اللدائن لتقليل تأثرها بالعوامل الجويه .

وبتزويد الجهاز بقاعدة تحميل افقيه اكتسب مساحة تثبيت ودعم واتزان عاليه نسبيا بحيث اصبح الاتزان وامكانية الحركة والدوران والانكفاء جيدا وجعلت أضلاع القاعده الخارجيه المتجاوره متساوية التوزيع والاتزان روعيت فيها تقليل قيمة الاحتكاك بالاجزاء القابله للدوران . وهى مصنوعة من قطاعات من الصلب خفيفة الوزن وعالية الصلابه والمقاومه .

وبتزويد الجهاز بالكرسيين المحوريين أحدهما على الآخر أصبح من الممكن تقليل العزم المؤثر على الصارى مثل العزم الفعال الناتج عن الرياح والتى

قد تؤدى عند اشتدادها الى سقوط أو انحناء أو انكفاء الصارى .

وتعمل عناصر الاستشعار على تحسس الفرق فى تعامد الشمس على المستقبل وتحول فرق شدة الاشعه الساقطه عن شدة أشعة الوضع العمودى الى اشارة كهربائيه تعمل على توجيه مجموعة الحركه الخاصة بها والمعنيه الى أن يتم الحصول على فرق مقداره صفر بين الاثنين ، وهكذا تعمل على المحافظة على تعامد اشعة الشمس على المستقبل وتتابع حركة الشمس النسبيه .

ويثبت أحد عناصر الاستشعار بالصارى والآخر بالحامل ويوصل كل منهما بمجموعة الحركه المعنيه توصيل فعلى مباشر .

٤ مزايا الجهاز :

اشارة الى ما ذكر أعلاه والى النتائج الفعليه لاختبارات جهاز تتبع مسار الشمس وتفصيل بيانات التصميم المقدمه لمكتب براءة الاختراع تتضح المزايا التى يقدمها هذا الجهاز فى رفع كفاءة الاستفاده من الخلايا الشمسية بتوفيره لامكانية الحركه المرنه الذاتيه التى تسمح بتتبع الوضع النسبى للشمس طوال النهار وجعل الأشعه متعامده دائما على المستقبل مع ما يوفره من ملائمة ميكانيكية حركته ومناسبة مواده للغرض المنشود .

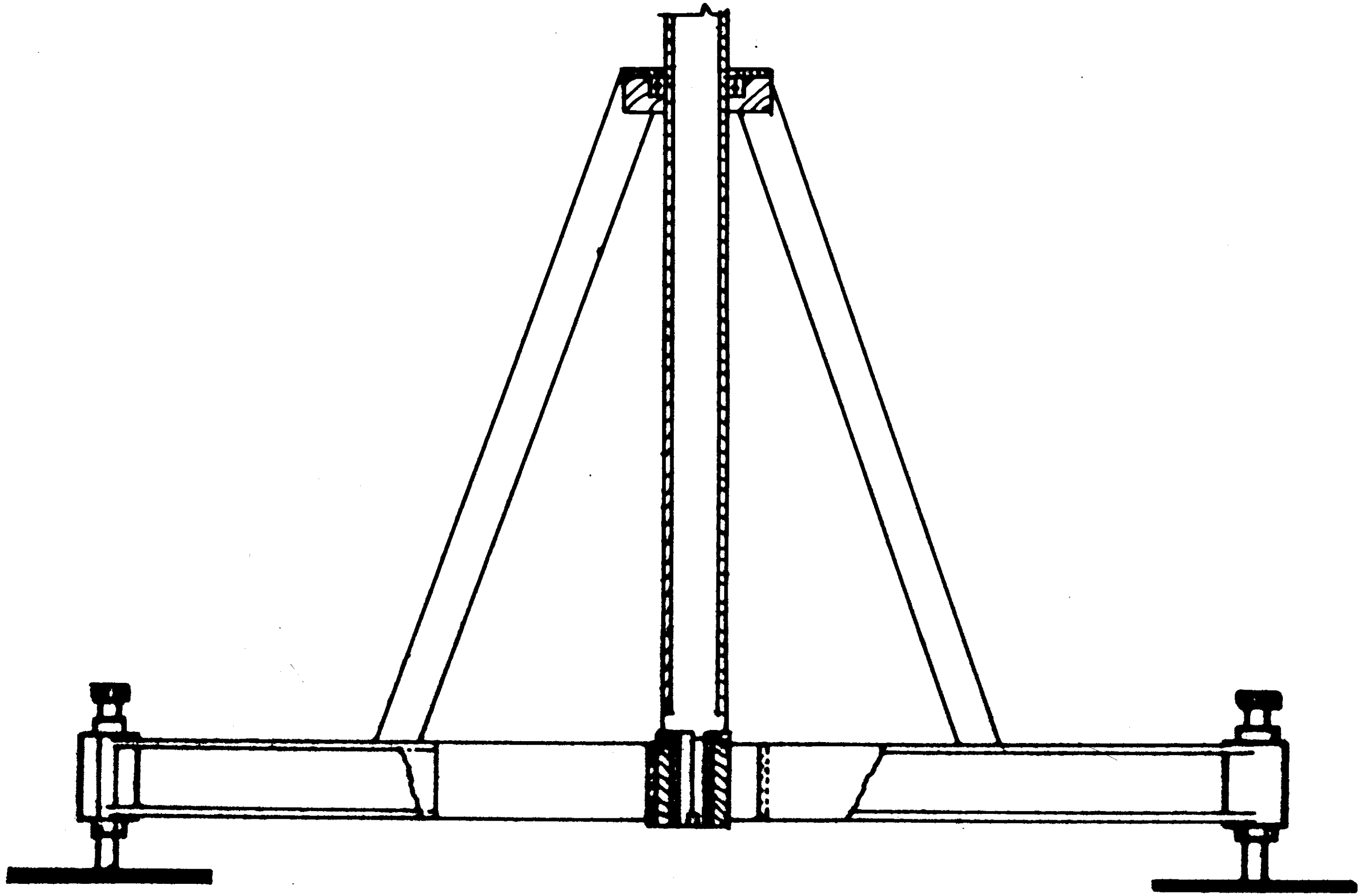
٥ خاتمة :

اعطت هذه الورقه وصفا اجماليا لاختراع تمثل فى جهاز تتبع المسار الشمسى لرفع كفاءة الخلايا الكهروضوئية وبالتالى الاستفاده الاكبر من امكانيات الطاقة الشمسية فى توفير الطاقة الكهربائية .

ومع ما يقدمه هذا الجهاز من مساهمة وايجابيات فى هذا السبيل فان المجال لازال مفتوحا لاستمرار الدراسة والبحث لمزيد من الفعاليات فى الاستفاده المثلى من طاقة الشمس فى توليد الكهرباء كما يؤمل أن تلحق هذه الدراسة دراسة أخرى عن تفاصيل آداء الجهاز واقتصادياته يتم حاليا اعدادها .

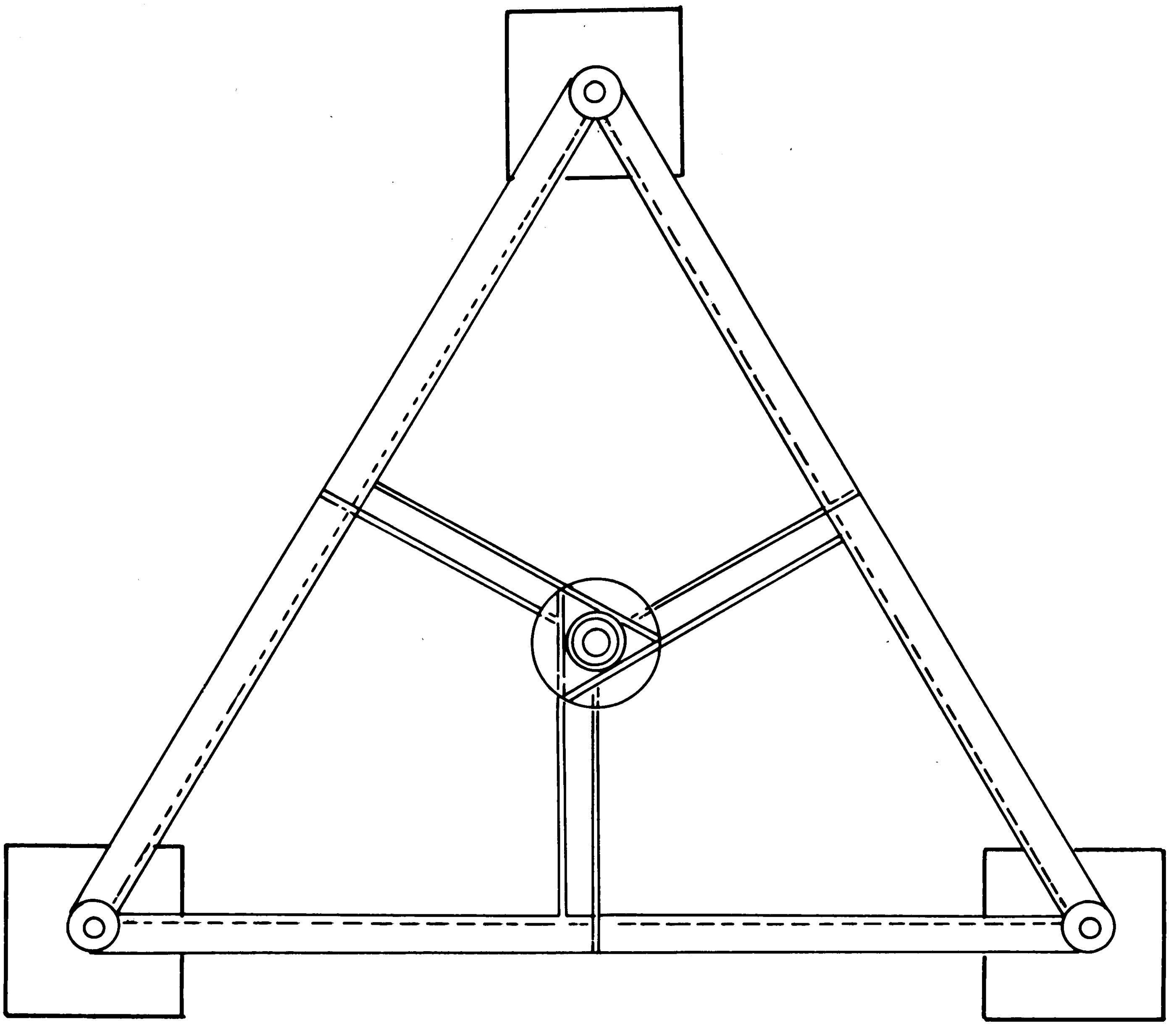
المراجع :-

(١) عبدالوهاب حسين نصرات ، وثائق وأوراق براءة اختراع جهاز تتبع مسار الشمس لدى مكتب براءة الاختراع بالمانيا الاتحادية ، ملف رقم ٨/٣٥٢٥٠٦٥ تاريخ التسجيل ٨٥/٧/١٣ ، تاريخ النشر ١٩٨٧/١/٢٢م .



شكـــــل (١)

مقطع جانبي جزئي للقطاع السفلي الحامــــل والقاعـــدة



شكل (٢)

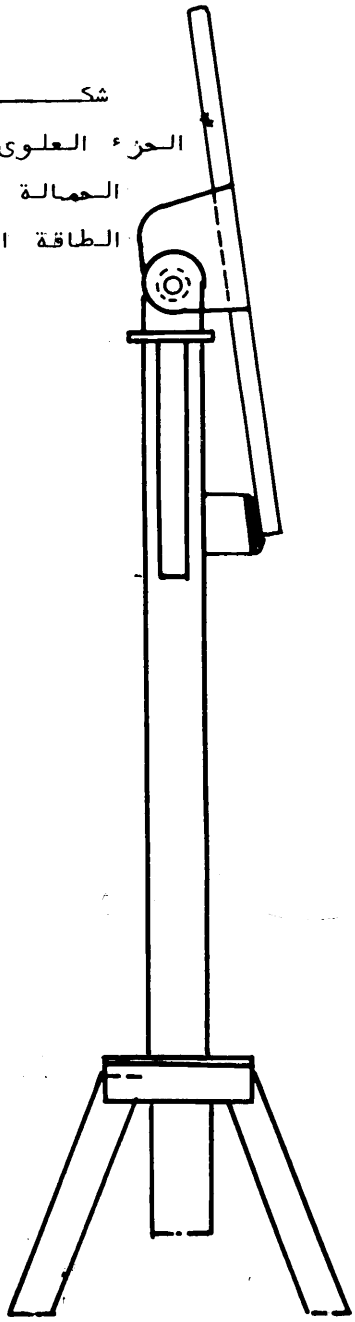
القاعدة وقاعدة التحميل

شكـــل (٣)

الجزء العلوى للسقالة مــع

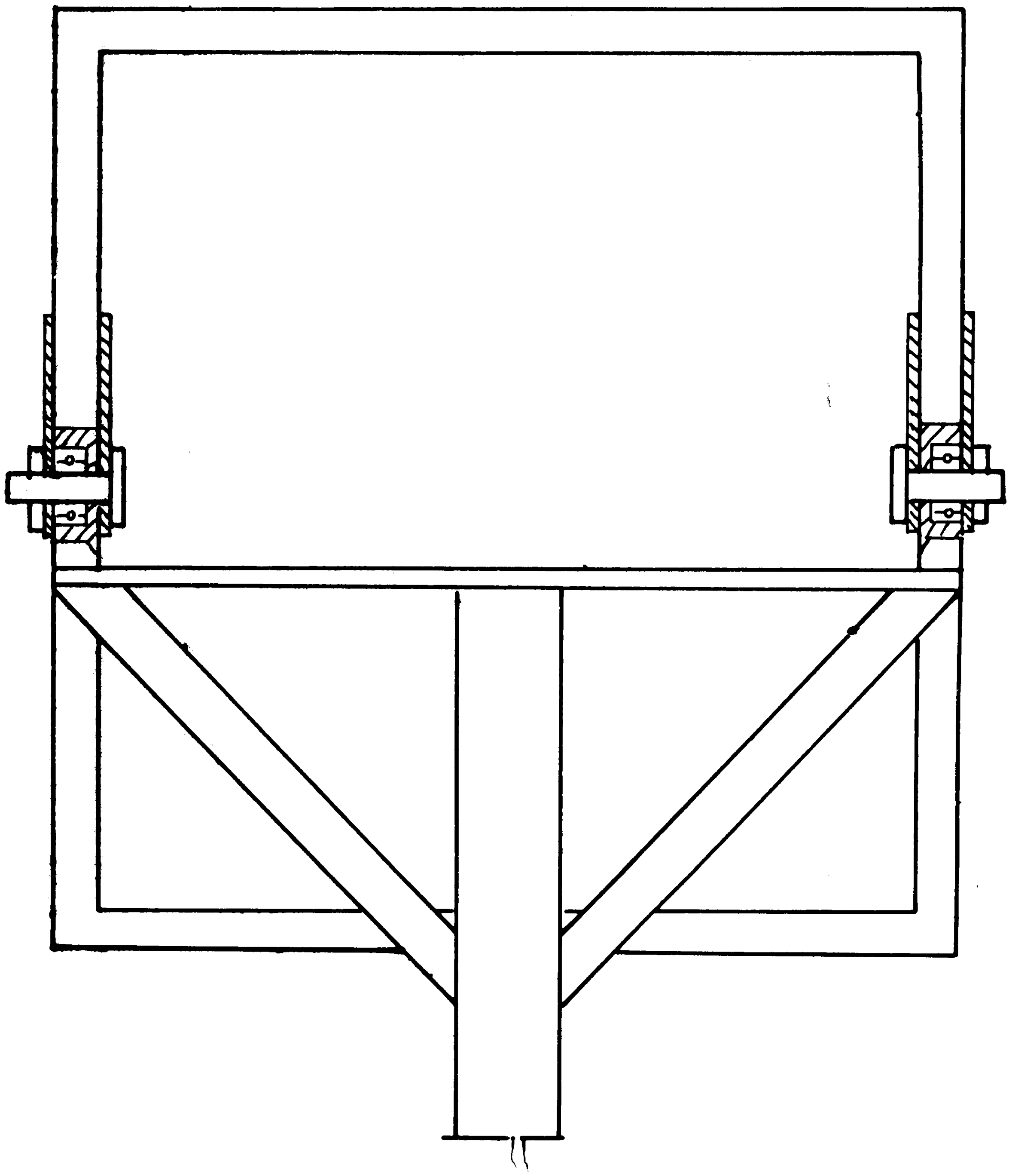
الحمالة لاحد مستقبلـــى

الطاقة الشمسيـــة



شكـــــــل (٤)

قطاع جزئى وقطاع عام خلفي للجزء العلوى للسقالة مع الحامل اللازم للمستقبل



INFLUENCE OF SUBSTRATE TEMPERATURES ON $CuInSe_2$ THIN FILMS

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ABSTRACT

P type $CuInSe_2$ thin films prepared by coevaporation technic were studied with the help of a Scanning Electron Microscope(SEM), a Reflection of High Energy Electron Diffractometer (RHEED) and a Spectrophotometer. The SEM micrographs show that the best films, with smooth surface topography, reasonable grain size and columnar growth, were obtained at 500°C. The RHEED study confirms the sphalerite structures for films at substrate temperatures $T_s \leq 400°C$ and chalcopyrite for $T_s \geq 450°C$. The Spectrophotometer study shows that the chalcopyrite and sphalerite structures exhibit band gap of about 1eV and of 0.88eV respectively.

1. INTRODUCTION

$CuInSe_2$ is a direct gap I-III-VI ternary semiconductor synthesised in the year 1953 by Hahn et al [1]. Its application in non-linear optics and optical communication has been realised for a long time [2] . In photovoltaic application, a solar cell with evaporated CdS on n-$CuInSe_2$ single crystal with conversion efficiency of 12% has already been reported [3] . In thin film technology, as emphasised today to provide an economically competitive source of electricity by lowering cell cost, different novel materials were investigated over the last more than a decade. But $CuInSe_2$ in chalcopyrite structure with band gap of 1.04eV, absorption coefficient of about $10^5 cm^{-1}$, unity quantum efficiency and good environmental stability, was found to be the most promising one. Thin film small area $CuInSe_2$/Cds heterojunction solar cell has already attained a conversion efficiency of 11% [4], the highest among all thin film cells. Moreover, a $CuInSe_2$/Cds or its variations either in single heterojunction or in multiple tandem cell still continue to be a viable candidate for a (10-15)% efficient terrestrial solar cell. But these devices still have a lot of drawbacks like low open circuit voltage, non-reproductibility, small area consideration etc.

However, the production of the basic $CuInSe_2$ films and understanding of its structural, optical and electrical behaviours are still in the state of laboratory research. The films developed by thermal evaporation [4,5] ,sputtering [6],spray pyrolysis [7], molecular beam epitaxy [8] and electrodeposition [9] yielded solar cells of average efficiency aroung 7-8%. Composition and other properties of $CuInSe_2$ films are strongly dependent on growth parameters. Selenium deficiency generally gives rise to n type conductivity. So, selenium flow rate should be adjusted to set selenium supersaturation ratio of 2 at suitable substrate temperature which ensures p type conductivity and chalcopyrite structure. The Cu-rich and In-rich films were found to behave differently in respect of their structural, optical and electrical properties and excess of Cu or In produced phases of selenides of copper and indium in the films [10] .

This paper discusses the influence of substrate temperatures on the structural and optical properties of p-$CuInSe_2$ thin films and correlates the optical parameters to the film structures.

2. EXPERIMENTS

P-type $CuInSe_2$ thin films were prepared by co-evaporation from the elements in a conventional diffusion pump vacuum chamber at pressure of about 10^{-6} torr. A crossed Cu-In source arrangement with a carbon block at the

centre was made with tungsten boat for copper and alumina coated tantalum boat for indium. The selenium source was a high capacity graphite Knudsen cell. The copper and indium deposition rates were controlled by feedback to their sources from an Electron Impact Emission Spectroscopy(EIES) detection system (Laybold-Infliction Sentinel), whilst the selenium rate was measured using a quartz crystal monitor. The substrates were supported in close thermal contact with a substrate table whose temperature could be controlled to +/- 1^{o}C up to a maximum of about 525^{o}C. For this work, we used Corning 7059 glass as substrate.

The surface topography was examined by a Scanning Electron Microscope (SEM) Cambridge S_1 50 in Secondary Electron Imaging (SEI) mode. For comparison, the micrographs of various films were taken at the same magnification and tilt angle. The compositional study was done by the same SEM using it in Energy Dispersive X-ray (EDX) imaging mode comparing the data with that of the standard sample. The crystalline quality of the deposited films was assessed by RHEED in a JEM 120 transmission electron microscope. Here the samples were mounted on a JEOL goniometer and a beam energy of 100KeV was used throughout.

For optical studies, the transmittance and reflectance data were recorded by a spectrometer Cary 17D in the light beam range 0.4 to 2.5 um. The reflectance measurements are very sensitive and has two components - specular and diffused. These components were measured individually and then together. Finally, these readings were averaged to get the actual reflectance. The specular reflectance was measured using a V-W mirror geometry accessory. The diffused and diffused plus specular reflectance measurements were carried out in an integrating sphere with Mgo reference.

3. RESULTS AND DISCUSSION

The SEM micrographs for three films deposited at temperatures 250^{o}C, 400^{o}C and 500^{o}C are shown in Figures 1 (a),(b),(c) respectively. Here, the surface condition and apparent grain size are found to improve with substrate temperature. However, the most interesting observation in this study is that columnar film growth is observed only for the film developed at substrate temperature of 500^{o}C.

In thin films a variety of structures can be observed amorphous, polyorystalline and epitaxial and Figure 2 (a), (b),(c) shows the RHEED photographs of some of our films. Here a clean sequence of structures can be observed as function of substrate temperature. Films deposited at or below 250^{o}C are totally polycrystalline with small grain size and they become more and more sharp with the

increasing substrate temnerature un to 400°C. However, in all these films no reflection characteristics of tetragonal structure are observed. Thus, these films must have a disordered Cu-In lattice resulting snhalerite structure. In films at 450°C $\leq$ Ts $\leq$ 500°C, traces of sunerlattice reflection characteristics of chalconyrite structure with fibre texture orientation are observed. Our nresent observation confirms the results obtained earlier by Don et al [11].

From these observations, it is evident that all films nrenared on Corning glass at Ts $\leq$400°C are snhalerite in structure. The formation of chalconyrite starts at Ts=450°C and for comnlete transformation it requires Ts=500°C.

The ontical nronerties of $CuInSe_2$ films denend strongly on their stoichiometry and crystalline nronerties or in turn on their growth narameters, such as substrate temperature, flow rate etc. The ontical absorntion co-efficients for these films are calculated using the generalised formula :

$$\alpha = (1/d) L_n ((1-R)^2 / T) \qquad (1)$$

Where R, T and d stand for reflectance, transmittance and thickness resnectively. The transmittance and reflectance comnonents data for a tynical film at T_s= 400°C are shown in Figure 3. Using equation (1), the ontical absorntion co-efficients for our films are calculated, and Figure 4 shows the results for some of them. Here the values of the absorntion co-efficients are found to increase with substrate temneratures or intern with imnroved crystalline quality. This observation sunnlements the results obtained by Don (5), who showed that rhe transmittance decreases with conner content of the film and cu-rich films give higher absorntion co-efficient than that of In-rich films.

The general exnression for the absorntion by excitation of electron across a band gan Eg is given by:

$$\alpha = (A/h\nu) \quad (E_g - h\nu)^n \qquad (2)$$

Where $h\nu$ is the nhoton energy. Thus a nlot of $(\alpha h\nu)^{1/n}$ against $h\nu$ will give the value of Eg and it is exnerimentally established for amornhous films n=1, for direct band semiconductor n=1/2, for indirect transition n=2 and for forbidden direct transition n=3/2. For our films different nlots are tried and found to satisfy one with n=1/2, the case for direct band transition. Such nlots for two tynical films of 260°C and 460°C are shown in Figure 5. The standard value of band gan for chalconyrite $CuInSe_2$ is taken to be 1.04 eV. However, the values renorted by different authors over the last decade vary widely in the range 0.81-1.04 eV(12,13). H.Neumann (14) exnlained their discrepancies in terms of snin-orbit snlitting in

chalcopyrite compounds. In our study all the films prepared at substrate temperature Ts $\leq 400^{\circ}C$ yield a unique band gap value of about 0.88 eV and those prepared at $400^{\circ}C \leq Ts \leq 500^{\circ}C$ give another unique value of approximately 1.0 eV. From our RHEED study it is confirmed the first series of films to be of sphalerite structure and the second series more or less to be of chalcopyrite structure.

The refractive index and extinction co-efficient of these films are also calculated by the method described by Manifacier et al [15]. Figure (6) shows the variation of these two parameters as a function of wavelength. Like other ternary compounds [16], very little variation of refractive index in $CuInSe_2$ with wavelength is also observed. Moreover, higher temperature films seem to have higher values for these two parameters. These behaviours can be justified from the observation of Gan et al [17] thatchalcopyrite structure gives higher reflectance than the sphalerite structure.

CONCLUSION

Since the structural, optical and electrical properties of $CuInSe_2$ are solely dependent on preparation conditions, the wide variation in the quoted values of different parameters of this film by different authors in literature may be linked up to their growth parameters. From our study it is evident that the films ~~xxs~~ possess a sphalerite structure for substrate temperatures below or at $400^{\circ}C$ and chalcopyrite above $500^{\circ}C$. Moreover, the sphalerite andchalcopyrite structures consistently exhibited band gaps about 0.88eV and leV respectively.

ACKNOWLEDGEMENT

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FIGURE CAPTIONS

Fig. 1. SEM micrographs for $CuInSe_2$ thin films at substrate temperatures: (a) 250°C, (b) 400°C and (c) 500°C.

Fig. 2. 100kV RHEED photographs of $CuInSe_2$ thin films at substrate temperatures: (a) 250°C, (b) 400°C and (c) 500°C.

Fig. 3. The transmittance T, specular reflectance R_S, diffused reflectance R_D and diffused plus specular reflectance R_{SD} data for a typical $CuInSe_2$ film at substrate temperature 400°C.

Fig. 4. Plots of optical absorption co-efficient against wavelength for $CuISe_2$ thin films at substrate temperatures: 300°C (O), 400°C (▲), 450°C (●) and 500°C (*).

Fig. 5. Plots of $(\alpha h\nu)^2$ against photon energy $(h\nu)$ for thin $CuInSe_2$ films at substrate temperatures: 260°C (+) and 460°C (⊕).

Fig. 6. Plots of refractive index and absorption co-efficient against wavelength for thin $CuInSe_2$ films prepared at substrate temperatures: 250°C (X), 300°C (O), 350°C (△) and 450°C (●).

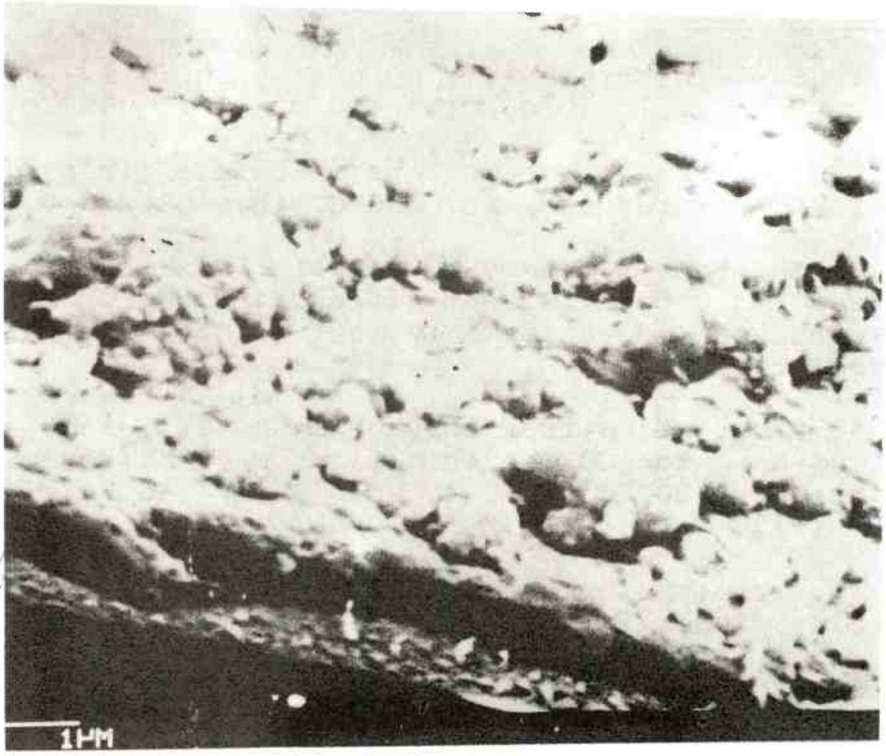


Fig. 1(a)

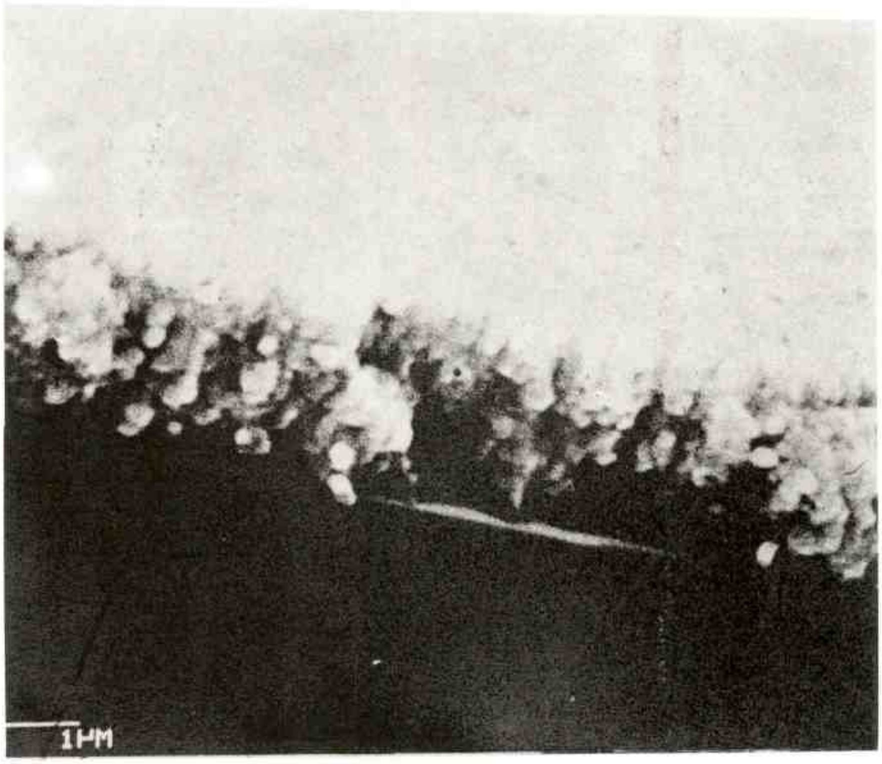


Fig. 1(b)

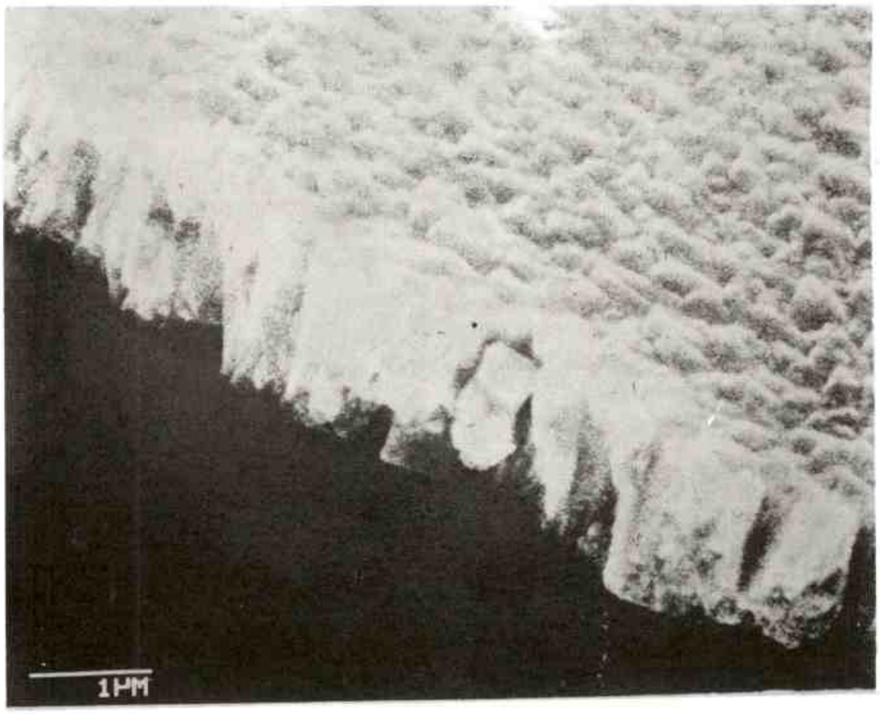


Fig. 1(c)

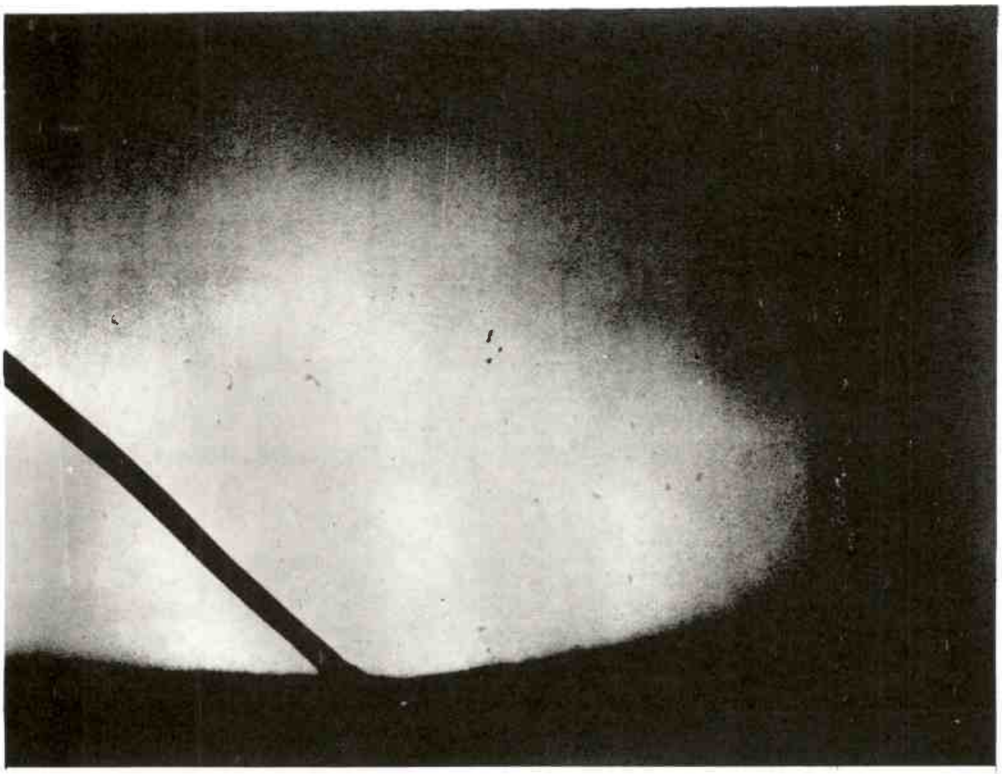


Fig. 2(a)

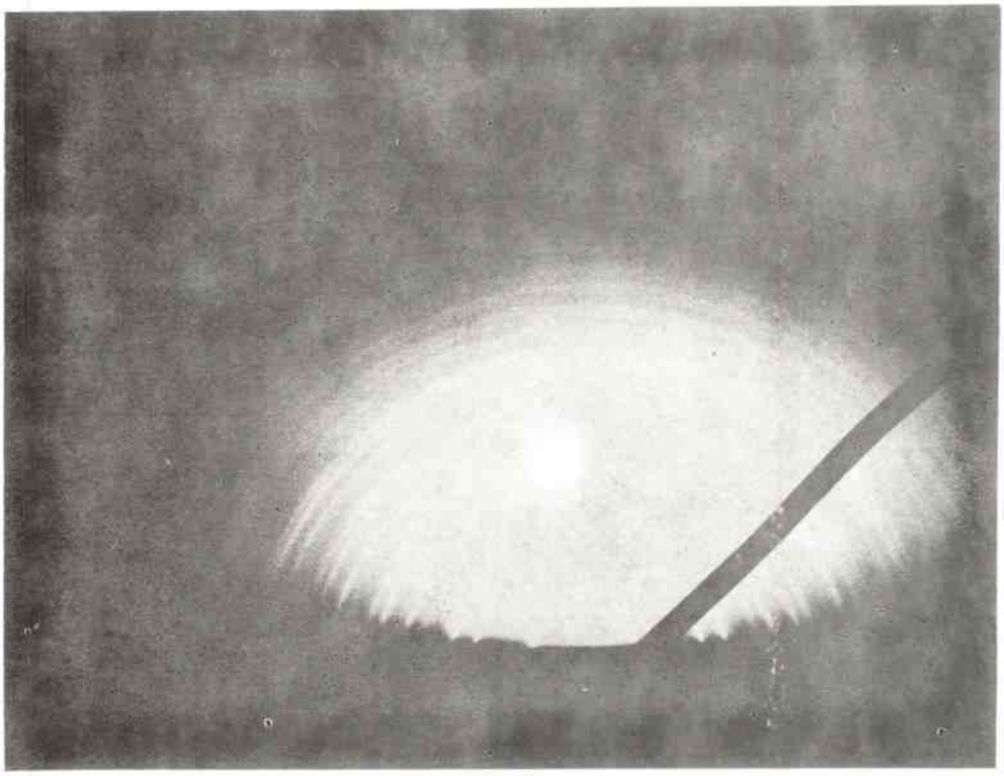


Fig. 2(b)

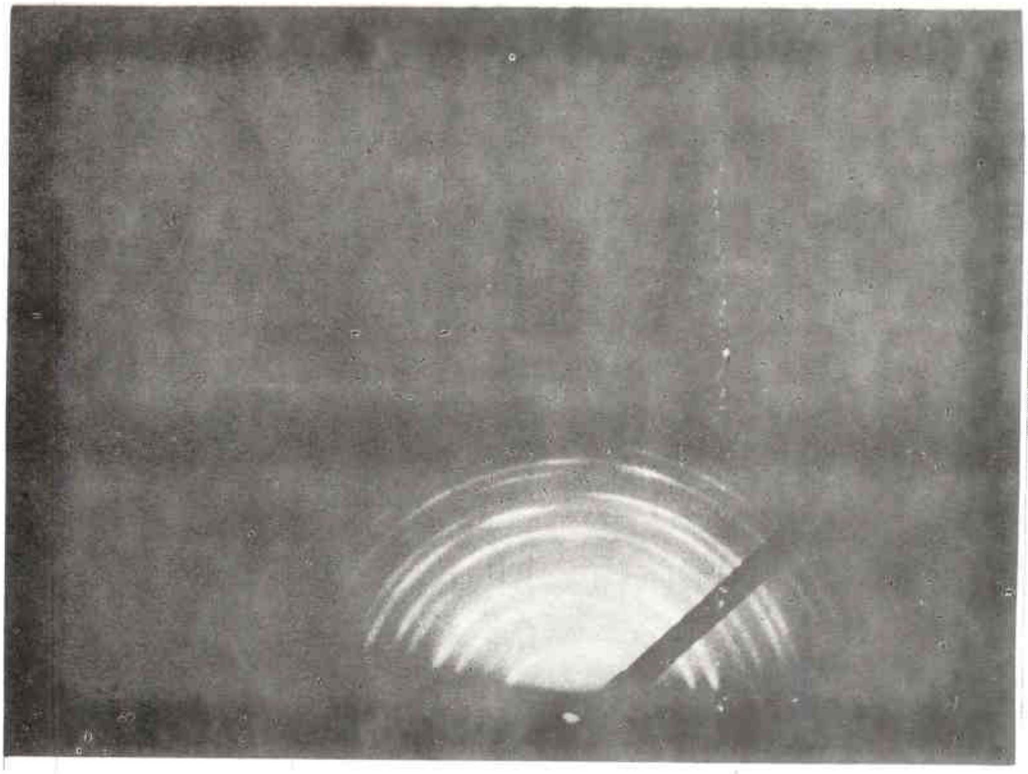
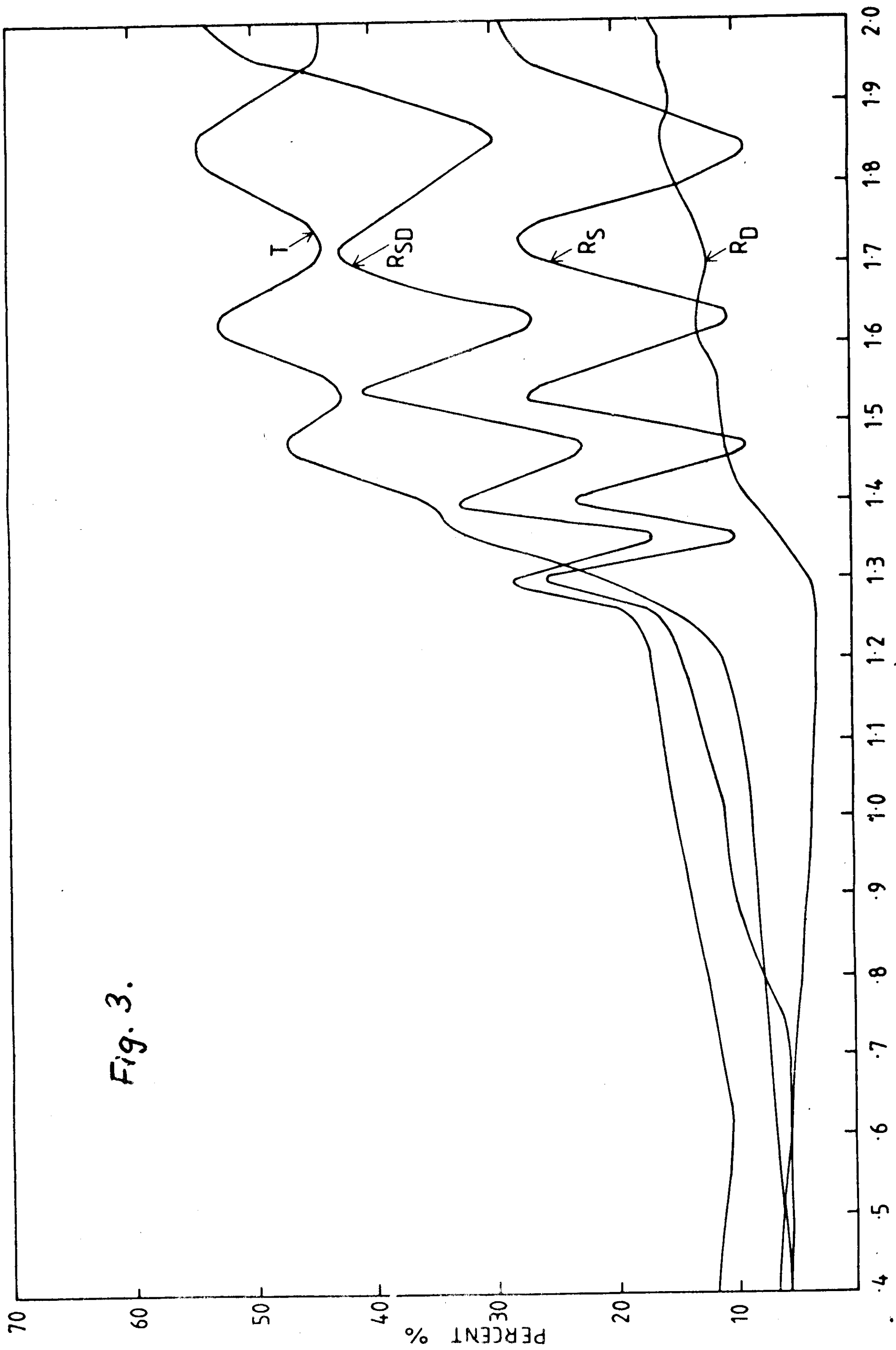


Fig. 2(c)



PERCENT %
70
60
50
40
30
20
10
λ (μm)
·4
·5
·6
·7
·8
·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
T
R_{SD}
R_S
R_D

Fig. 3.

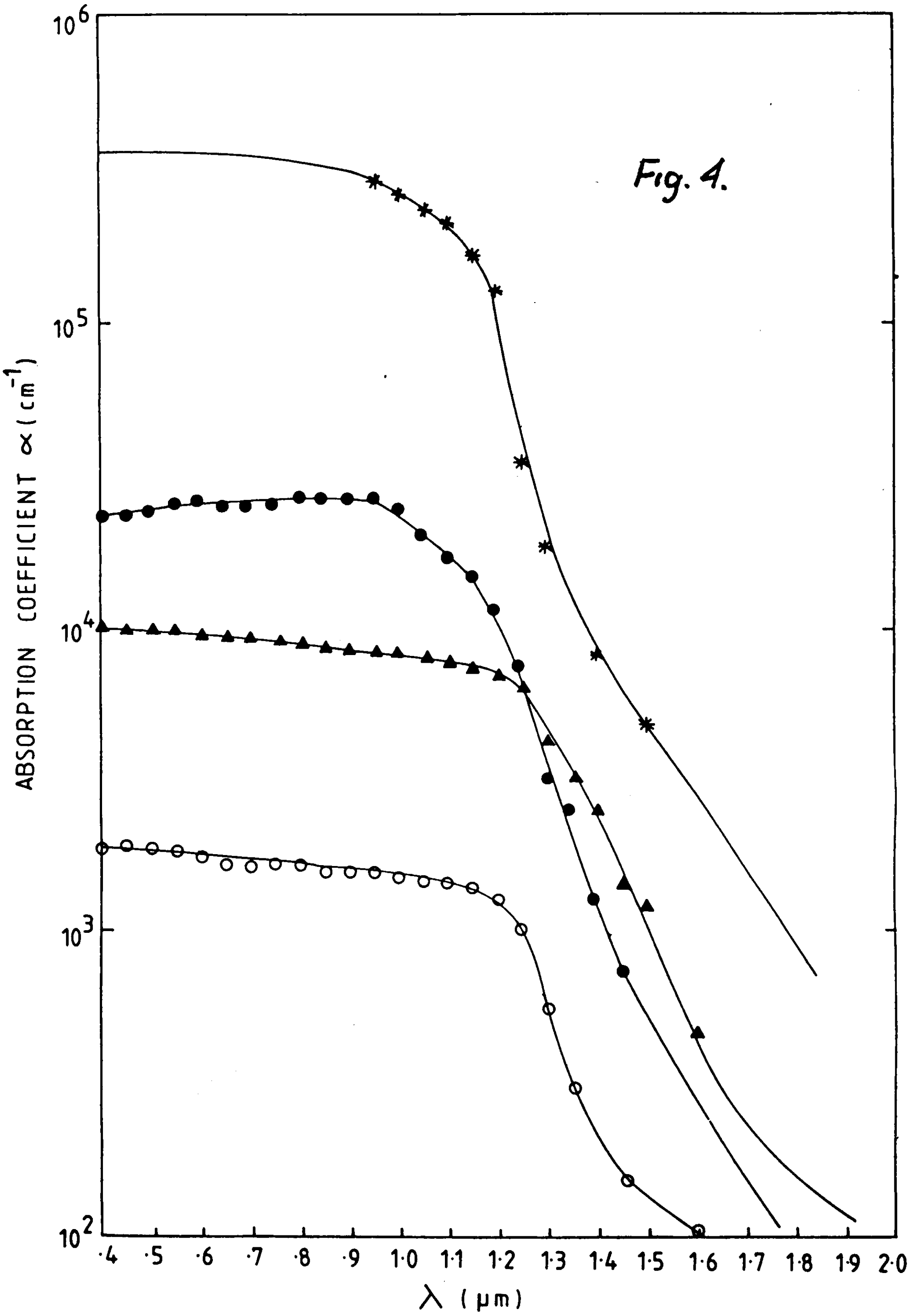


Fig. 4.
ABSORPTION COEFFICIENT α (cm⁻¹)
10^6
10^5
10^4
10^3
10^2
·4 ·5 ·6 ·7 ·8 ·9 1·0 1·1 1·2 1·3 1·4 1·5 1·6 1·7 1·8 1·9 2·0
λ (μm)

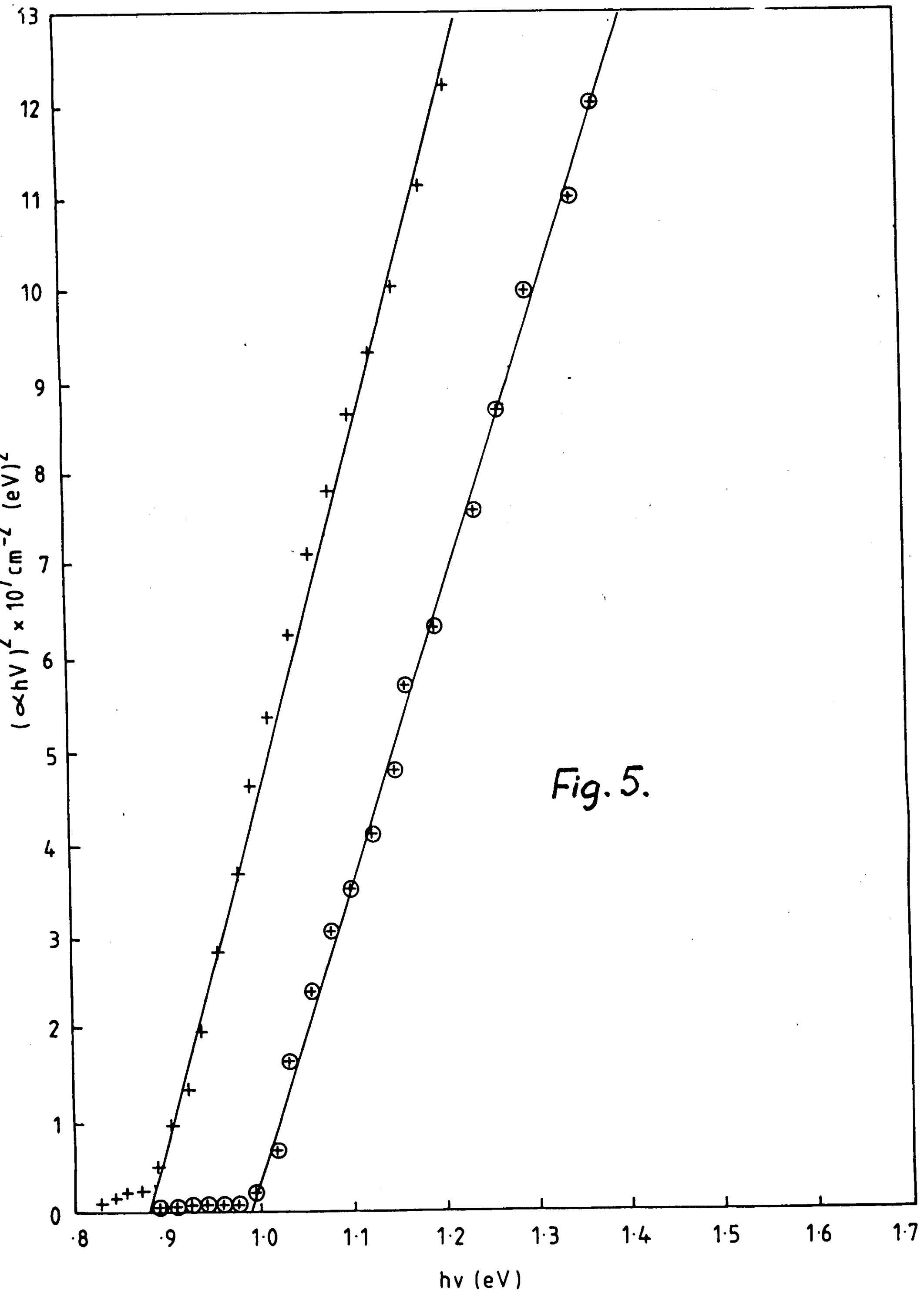

13
12
11
10
9
8
7
6
5
4
3
2
1
0
·8
·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
$(\alpha h\nu)^2 \times 10^7 cm^{-2} (eV)^2$
hν (eV)

Fig. 5.

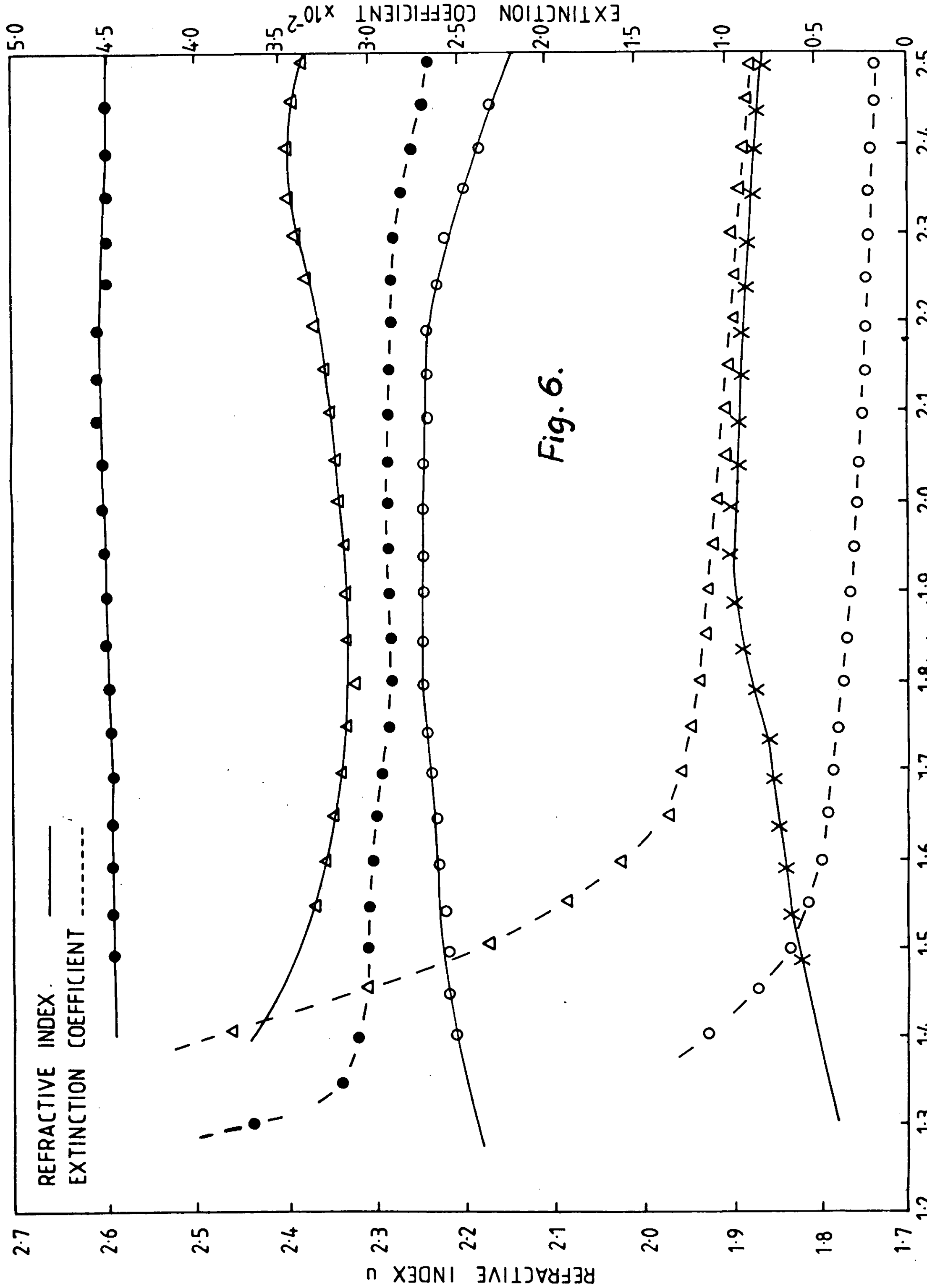

REFRACTIVE INDEX
EXTINCTION COEFFICIENT
EXTINCTION COEFFICIENT x10^-2
REFRACTIVE INDEX n
λ (μm)

Fig. 6.

SOLAR ELECTRICITY AS A MOTOR OF RURAL DEVELOPMENT

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ABSTRACT

Rural development can benefit from solar electricity in a multitude of ways. Micro electrification is suggested as a first step and details of a current micro electrification project in The Gambia are presented. Also rural industries can be developed using PV panels. Appliances using 12V DC are readily available, making conversion to 220V AC less necessary. Tracking and moderately concentrating the sun may considerably help to lower the cost of PV produced electricity.

1. INTRODUCTION

Rural development is a necessity in most developing countries in order to lower the rate of migration into urban areas. This development includes social services such as schools and health centers, improved farming techniques and infrastructure, and small scale village industries.

Access to electricity is necessary if modern technology is to be employed in the development process. In the absence of electric grids, electricity has to be produced in situ. Solar panels can begin to compete favorably with diesel generated electricity in many instances when the amount of electric energy required is moderate (1). Basic requirements of a majority of households in rural areas of developing countries have been estimated to a few Wh per day, clearly most economically produced by photovoltaic techniques. Even basic community needs of electricity could well be met by PV systems (2). Such an introduction of electricity is usually referred to as pre-electrification (3).

The present paper deals with several aspects of rural electrification. Low-cost micro electrification is suggested as a first step and details of a current micro electrification project in The Gambia are presented. This project includes solar rechargeable flashlights for households,

solar battery chargers for radios in primary schools, and solar driven physics laboratory equipment for secondary schools.

The possibility of rural industrial development using photovoltaic panels is then discussed. The cost per kWh used in manufacturing is much lower than the cost per kWh used by other sectors of the community, since the industry's electricity usage may be delivered directly from the PV panel and the use of costly battery banks is minimized.

Different types of village scale industries employing solar driven high-tech equipment would be possible. It is proposed that 12V DC equipment should be used and the results of a preliminary survey of such equipment are presented.

Furthermore, it will be shown that tracking the sun and using moderately concentrating devices may be economically favorable, especially when the PV generated electricity is directly used by motors or other equipment. A cornet type concentrator developed by SERC and suited for use with PV cells is presented. One of the virtues of the square cornet is the even distribution of the concentrated sunlight at the exit aperture (4). Another virtue is that only approximate or intermittent tracking of the sun is required since acceptance angles can be made fairly large (5).

2. MICRO ELECTRIFICATION IN THE GAMBIA

In the present study, several pilot projects of micro electrification activities in The Gambia will be performed. They all include technical test (in Sweden) of suitable equipment, implementation in The Gambia incl. maintenance training, monitoring the use of the equipment, and evaluation of the project. The following projects are planned:

* Flashlights with rechargeable batteries in households.
* Solar battery charging for school radios.
* Solar powered school laboratory equipment.
* Insolation measurements.

We hope to be able to show that micro electrification can be successfully implemented in a developing country. When solar energy has got a foothold in a rural area, continued solar electrification can play a significant role in the development process (6).

2.1 Energy Situation in The Gambia.

The Gambia is situated at latitude 13 degrees north, i. e. between the tropics. This implies, among other things, that the altitude of the sun at noon is between 80 and 90 degrees (90 degrees = zenith) in the summer and at least 66 degrees in the winter (while in for example Borlänge, the sun's altitude at noon varies between 6.5 and 53.5 degrees over the year). The length of the day is fairly constant, 12 hours throughout the year, slightly longer in the summer than in the winter. The rainy season, with alternating showers and sunshine, takes place during the summer.

The consequence of all this is that the insolation varies very little over the year. Measurements done at Yundum (the international airport) indicate that the number of daily sunshine hours varies between 6.0 in July and 9.5 in February, monthly mean values. The total insolation varies even less, between 5.0 kWh/sqm in August and 6.5 kWh/sqm in April, monthly mean values. Yearly average is 5.7 kWh/sqm and day (as compared to middle Sweden 2.5 kWh/sqm and day). These and other figures in this section are from ref. (7).

The Gambia consumes yearly about 15 TWh energy (uncertain figures. Sweden consumes about 400 TWh). Some 70 % of the energy is biomass (fuel wood) and the remainder imported oil. Charcoal production is prohibited since 1980 in order to conserve wood. A factory that produces briquettes (wood substitute for cooking purposes) from peanut shells is running and supplies 1 % of the country's energy needs. Electricity is mainly available only in Banjul and for the tourist hotels.

As evident from the insolation figures, the prospects for renewable energy using the sun are quite good. The government has therefore established GREC, The Gambia Renewable Energy Centre. The Centre is to work under the Energy Department of the Ministry of Economic Planning and Industrial Development (MEPID).

Today, only one installation in The Gambia produces solar heated water. It is situated at the Hotel Training School outside Banjul and has been running since 1980. A minor plant for production of fresh water from salt water (solar still) is running since 1983 in Brikama. An investigation of possibilities to establish production of solar water heaters and to build a pilot plant with photovoltaic cells for water pumping, tele communication, etc. is proposed by GREC. Out of twelve suggested future projects, three deal with solar energy: solar water heating, photovoltaic cells and a solar dryer for farmers products. Obviously the goals are modest, but the decision to establish GREC indicates an official interest in solar energy.

GREC takes part in a West African organisation for solar energy cooperation called CRES, CEAO/CILSS Centre Regional d'Energie Solaire, consisting of centers in nine countries.

2.2 Presentation of SERC

The project will be accomplished within Solar Energy Research Center, SERC. SERC is a part of the Faculty of Technology, University College of Falun/Borlänge. SERC was established 1984, but solar energy R&D activities had been going on at the College for several years prior to 1984.

Present research staff totals five and technical staff four. The yearly budget amounts to about SEK 2.0 million. Half of this comes from a 3-year grant from the Swedish National Energy Administration (STEV), half from project grants.

Present R&D activities of SERC include
- computer simulation of solar heat plants,
- evaluation of solar heat installations,
- solar electricity in developing countries,
- concentrator geometries and solar materials.

2.3 Method and Procedure

The goal of the Gambian project is, generally, to find a technology level of photovoltaic solar energy that can be implemented in rural areas of developing countries and at the same time make way for future larger projects. The goal is also, specifically, to develop suitable equipment for implementation.

In the present study, four different projects with increasing technical, and thus implementational, difficulties will be performed. Technical details of the projects will be given in the next section. Each project will follow these steps:

(1) Choice, technical test and primary technical evaluation of equipment. The more complicated projects include technical development as well.

(2) Preparations of implementation. Choice of counterparts (people, schools, workshops).

(3) Implementation. Training of counterparts.

(4) Monitoring the use of equipment. This will be done regularly by personnel from GREC and at intervalls by personnel from SERC, and include help with management, spare parts and reparations.

(5) Evaluation. This will be done in parallel with the monitoring by observing and questioning. Technical function and usefulness of the products will be evaluated as well as attitudes and knowledge levels of counterparts. Others, like representatives of CRES, will get chances to follow the projects.

2.4 Technical Descriptions

2.4.1 Flashlights with Rechargeable Batteries.

We have investigated one Swedish-made self-contained unit with flashlight, batteries and solar cells all in one housing. While the results were far from convincing, further tests of other examples will be done.

Very reliable small battery-chargers as well as flashlights are readily available and can be used as separate units. They are slightly more difficult to use but seemed to work well in a very preliminary test in Tanzania (8).

It should here be pointed out that access to flashlights may help the introduction of wood saving wood stoves; the light from such a stove is much less than from an open fire and may have to be replaced (9). Whether this argument is valid in The Gambia is presently not known to us.

2.4.2 Solar Battery Chargers for School Radios.

The cheapest solar battery chargers can charge only small (type R6) batteries. The first tests have indicated that such chargers and batteries (used in holders) provide sufficient power for the radios common in Gambian schools. This combination might, however, prove to be too marginal in the long run. Therefore, also a combination of a larger (but still small) photovoltaic panel and battery holders with larger batteries will be tested.

This is a project which, if it works, can have a fast and positive impact. All primary schools in The Gambia, and there are 161 of them, are equipped with radios (provided by UNICEF) and the radio station in Banjul frequently sends school programs. Lack of batteries and lack of funds to purchase batteries prevent the majority of schools from using their radios.

2.4.3 Solar Powered School Laboratory Equipment

We have constructed two experiment kits for the Futures' Museum in Borlänge. One is a small box with lampholders, bulbs, electric motor, switch, battery, cables, and contacts. It is intended for the very basic learning of electricity and could be developed into a solar powered unit. The other one is an experiment kit in digital electronics and an instruction book comes with it (10). Digital electronics draws very little current so the kit is easily converted to solar. The book (or parts of it) would have to be translated into English, since it is presently only available in Swedish. While the first kit is suitable for primary schools, the second kit is intended for the senior technical high school.

Other commercially available kits in electricity, analog electronics, etc. are available and might prove useable.

2.4.4 Insolation Measurements

We are in the process of developing simple solar measuring instruments using photovoltaic cells as light-sensitive elements. They can be used either with manual reading of an amperemeter or coupled to a small computer using an interface with AD-converter. Both kinds of equipment are planned to be brought to The Gambia and set up in a couple of places. Detailed knowledge of the insolation is almost nonexistant and vital for the future of solar energy in the country. Tests of how such a meter performs in a tropical country will hopefully lead to a reliable and inexpensive instrument which is easy to use and thus having prospects to become widely used.

3. RURAL INDUSTRIAL DEVELOPMENT USING PV PANELS

3.1 Solar Powered Electronics Workshop

The possibility to build small-scale but high-tech village industries and the possible impact of such industries on rural development has previously been discussed by us (6). A first step in the development of such a concept would be to construct and equip an electronics work-

shop aimed at servicing (solar powered) household electric appliances; firstly flashlights and radios, later maybe fluorescent lamps, TV sets, refrigerators, etc. Maybe such a shop could be equipped to build photovoltaic panels from solar cells, electronic regulators for solar electricity systems, etc.

A small industry's demand of electric power is typically during daytime, so a high percentage of its electricity need may be delivered directly from the PV panel. This is favorable, since battery banks are costly and not always trouble-free (11).

There is no general agreement whether 12V DC or 220 V AC systems should be preferred (12). We have however found a multitude of 12V equipment intended for mobile developed country use, and therefore believe that the higher simplicity and efficiency of the 12 V system speaks strongly infavor of it.

3.2 Survey of 12V DC Equipment

We have made a survey of 12V DC equipment available on the Swedish market. Our list is by no means complete, but we have entries under the following headings (with examples given):

3.2.1 Computers and Electronics

Computers and printers (Bondwell, Epson, Toshiba), photo copier (Canon; soon available), oscilloscope (Hitachi), soldering equipment.

3.2.2 School and Education

Tape recorder, radio, TV, physics experimental equipment (PHYWE).

3.2.3 Domestic

Electric bulbs, fluorescent tubes, refrigerators (Electrolux), immersion heater, percolater, vacuum cleaner, flat-iron, shaver.

3.2.4 Tools and Motors

Drilling-machine, circular saw, universal saw, grinding and polishing machines, engraving pen (Minicraft, Black&Decker), DC motors, fans, water pumps (Bosch), compressors, electric winch.

3.2.5 Communication

Outboard motors (Johnson, Mercury), motor cycle, truck (Bendix), intercom, local telephone, radio telephone.

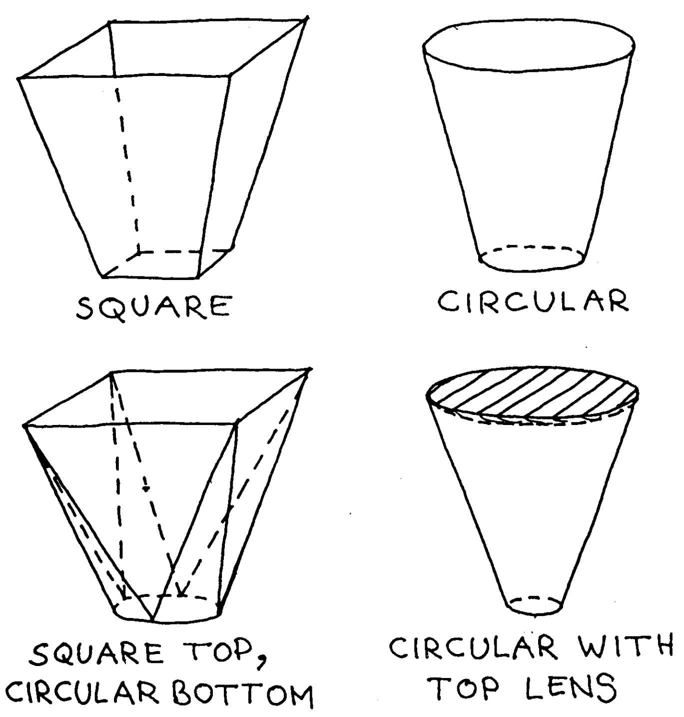
4. TRACKING AND CONCENTRATING

There are certain advantages by concentrating the sun. Reflecting materials cost only a fraction per sqm of what PV cells do. Several authors indicate lower cost per kWh from PV concentrating collectors (13, 14). Low concentrating systems and even non-concentrating flat plate tracking systems have also been shown to be cost effective (15, 16). We have constructed a cornet type PV concentration system, which has qualifications to become quite cost effective, especially for small industry and other applications, where no or little storage is required.

4.1 The cornet concentrator photovoltaic panel

Cornets belong to a class of concentrators called nonimaging concentrators. The cornet geometry has been mathematically described elsewhere (5). One virtue of a nonimaging concentrator is that a large acceptance angle d is possible to achieve. The theoretic maximum concentration C(max) is given by $C(max) = 1/\sin^2 d$ (17).

FOUR DIFFERENT CORNET GEOMETRIES



We have done calculations and computer analyses of the cornets shown in the figure: (a) square cornet, (b) circular cornet, (c) circular cornet with a lens, and (d) cornet with square

top and circular bottom (4, 16). The optimum geometry for PV applications seems to be the combination of square solar cell and square cornet, since this is a concentrator without "hot spots" at the bottom.

We have performed clear sky measurements of the maximum electric power output from 10 cm x 10 cm standard square Solarex PV cells without concentration and with six different cornet concentrators made of polished aluminum. The only "customizing" we did was to solder two 1.5 mm copper wires onto four points each of the surface grid of the cell. The results are summarized into the empiric formula

$$P(C)/P(1) = 0.44 + 0.56\,C \quad (1)$$

where P(C) is the output at geometric concentration C and P(1) is the output with no concentration. The value 0.56 (instead of the ideal 1.0) is due to the fact that diffuse light cannot be concentrated, that the reflectivity of the aluminum was about 0.75 and that cell temperature increases with concentration. The formula is applicable up to C = 4.5.

4.2 Tracking the sun

When concentrators are used, the sun has to be tracked. The use of cornets decrease the requirements of precision. As Robbins (18) has described, so called passive sun-tracking using freon-filled tubes can easily track the sun within 2 degrees. With an acceptance angle of 5 degrees, manual redirection every 40-60 minutes will work fine. With higher cornets, 10-15 degrees acceptance angles are easily reached with correspondingly longer intervals between redirections.

Tracking, even if it is un-precise, increases the energy output from a solar panel even if it is just a flat plate panel that doesn't need tracking. The table compares the daily output from a tracking and a fixed (latitude tilt) collector during a clear day (beam and diffuse light) at some different locations and dates. The output from the tracking collector is between 32 and 53 percent higher than the output from the fixed collector.

Table
Relative daily clear day outputs from PV collectors

Location		Equator		Tropic	
Time of year	Equinox	Solstice	Summer solstice	Equinox	Winter solstice
Tracking coll.	100	97	111	97	77
Fixed coll.	76	68	73	74	58

The difference is even more striking if we regard the special case of a DC motor running directly on the current from a PV panel. In a crude mathematical model, current output from the panel is proportional to insolation and the work done by the motor is proportional to the current squared. Tracking the sun increases the work done between 49 and 89 percent.

A third comparison between the two geometries uses the fact that the output from a tracking collector is fairly constant during several hours of a clear day while the output from a fixed collector has a typical "Cosine" shape. Since the use of electricity in a small industry can be assumed to be fairly constant throughout the day, extensive use of electricity storage can be avoided only if tracking is employed.

Calculations show that the power from a tracking collector exceeds 75 % of (yearly) maximum around 8.5 hours per clear day at the equator and between 6.5 and 9.5 hours per clear day at the tropic, depending on the season. The same figures for a fixed latitude tilt collector is only around 4.5 and between 3 and 5 hours, respectively. The improvement is striking and strongly suggests the use of tracking for industrial and similar applications.

ACKNOWLEDGEMENTS

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" اختيار أنسب الاحجام لانظمة الضخ بالخلايا الشمسية التى تستخدم تخزين المياه "

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الملخص :

رغم انخفاض أسعار الخلايا الشمسية فى السنوات الاخيرة الا انها مازالت تمثل الجزء الاكبر فى تكاليف أنظمة الضخ التى تستخدمها وللتقليل من التكلفة الكلية للنظام يلزم استخدام اقل حجم ممكن من الخلايا يستطيع أن يواجه الاحمال المطلوبة على مدار العام والاسلوب المقترح استخدامه يعتمد أولا على توفير أكبر قدر ممكن من البيانات عن مكان الاستخدام، وكل مايمكن توفره عن الظروف المناخية عن المكان وكذا توفير بيانات عن الاحمال المطلوب مواجهتها على مدار العام ومتوسطها السنوى وأقصى وأقل الاحمال على مدار العام، ثم نوع الاستخدام المطلوب للمياه سواء اذا كان للاستخدام المنزلى او الرى او كليهما معا .

وقد وجد أن النقاط التالية يجب معالجتها باهتمام كبير :

1ـ تغير قيمة الاشعاع الشمسى على مدار السنة وتعظيم الاستفادة منه عن طريق استخدام أنسب زوايا الميل لكل فصل .
2ـ تغير مستوى الاحمال على مدار العام .
3ـ تغير درجة حرارة الجو المحيط وبالتالى درجة حرارة تشغيل الخلايا .
4ـ استخدام قيم لكفاءة المعدات المستخدمة من واقع الخبرة الحقلية .

1- مقدمة :

يواجه استخدام منظومات الخلايا الشمسية فى ضخ المياه فى هذه المرحله صعوبة وذلك لارتفاع تكاليفها الاستثمارية ويمثل ثمن الخلايا الشمسية منفرده الجزء الاعظم من التكاليف الاجمالية للمنظومة، ورغم ذلك فان الانخفاض المتوقع فى ثمن الخلايا

وارتفاع أسعار الوقود العادى حسب موءشرات السنوات الاخيرة يعطى الامل فى أن يصبح استخدام منظومات الخلايا الشمسية اقتصاديا وذلك بالمقارنة بطرق الضخ الاخرى. أما وأن تدخلت أبعاد اخرى مثل الحاجة الى ضخ المياه فى المناطق النائية التى يصل اليها الوقود التقليدى بتكاليف باهظة بالاضافة الى عدم توفر ضمان استمراره فان استخدام الخلايا الشمسية يصبح أمرا لابد منه لاستمرار الحياة والنشاط الانسانى فى هذه المناطق النائية التى غالبا ما تتمتع فى مصر وفى المنطقة العربية كلها بأشعاع شمسى مناسب جدا للاستغلال . ولتحسين الموقف الاقتصادى لضخ المياه بالخلايا الشمسية فانه يلزم تصميمها بطريقة جيدة للحصول على أكبر فائدة من المنظومة وتقدير قدرتها المناسبة حتى تصل لاقل التكاليف الممكنة مع احتفاظها بامكانيات مواجهة الاحمال المطلوبة .

وبناءا على ذلك فان الهدف من هذا العمل هو اقتراح اسلوب منهجى لتصميم نظم ضخ المياه بالخلايا الشمسية بحيث يتناول حجم مناسب من التفاصيل للوصول للتصميم الامثل على أن يعطى أقل تكاليف ويستخدم النظام عند أعلى كفاءة ممكنه .

2 - البيانات المطلوبه للتصميم (1) :

للحصول على أفضل تصميم يجب استعمال بيانات أدق ما يمكن كمعطيات للتصميم وتنقسم المعلومات اللازم توافرها الى ثلاث مجموعات :

2-1- بيانات عن موقع الاستخدام .

2-2- بيانات عن الاحمال المطلوب مواجهتها وظروف الاستخدام .

2-3- بيانات عن انظمة الخلايا الشمسية المتوفره واسعارها .

3 - الاسلوب المقترح لتحديد الحجم المناسب للخلايا الشمسية :

3-1- اختيار حجم التخزين المناسب وكذا الحد الادنى ويعتمد على :

(أ) الحمل المطلوب فترة عدم ظهور الشمس لعدة أيام .

(ب) احتمال حدوث عطل بالنظام .

(ج) التغيرات المناخية بين فصول السنه .

(د) مدى المرونه المطلوبه من المنظومه .

(هـ) نوع الاستخدام سواء للشرب او للرى او كليهما .

3-2- حسابات الاشعاع الشمسى (2) :

اذا كانت ك = شدة الاشعاع الشمسى الكلى على السطح الافقى فى المكان .

ت = مقدار الاشعاع المتشتت من الاشعاع الكلى على السطح الافقى .

ش = مقدار الاشعاع المباشر على السطح الافقى .

فان ش = ك ـ ت (1)

ويمكن حساب الاشعاع المباشر على سطح الخلايا الذى يميل على الارض بزاوية ميل م حسب المعادلة :

$$ش_م = \frac{ش جا (م + أ)}{جا أ} \qquad (2)$$

حيث أ = زاوية ارتفاع الشمس عند الظهيره

$$= 90^{\circ} - ع \pm ح \qquad (3)$$

ح = زاوية انحدار الشمس

$$= 45ر23^{\circ} جا (985ر (234 + ى)) \qquad (4)$$

حيث ى = رقم اليوم الممثل للشهر فى السنه

وتكون شدة الاشعاع الكلى على السطح المائل

$$ك_م = \frac{ش جا (م + أ)}{جا أ} + ت \qquad (5)$$

ومن معطيات الاشعاع الشمسى المتوسط لكل شهر فى السنه على السطح الافقى نحسب لمتوسط الشهرى للاشعاع الكلى على السطح المائل مستخدمين المعادله رقم

وذلك يعتمد على زاوية ميل الخلايا التى يتم اختيارها حسب الفصل على مدار السنه .

ومن المعروف أن تغيير زوايا ميل المجمع الشمسى يعطى كثافة أشعاع أفضل على السطح المائل ولذا يجب الاستفادة بقدر الامكان من هذه الظاهرة مع عدم زيادة التكاليف بانشاء نظام خاص لتتبع الشمسى ولكن يمكن الاكتفاء بتغيير الزاوية مع تغيير فصول السنه فقط .

3-3- حسابات الاحمال والانتاج المتوقع للمضخه المستخدمة :

(أ) من بيانات الاحمال الموجودة فى البند 2-2 يمكن حساب الحمل اليومى المتوسط على مستوى السنه بالكامل وكذا الحمل اليومى كمتوسط شهرى لكل شهر على مدار السنه .

(ب) من منحنيات الاداء ومن الخبرات السابقة فى المجال التطبيقى نختار الكفاءة الكلية للمضخه والموتور والمحول ($كف_{م م م}$) .

(ج) يمكن حساب كمية المياه التى يمكن للمضخه أن تنتجها(ف) باستخدام القدرة القصوى الاسمية (قأ) عند الظروف المعيارية (100 مليوات/ سم^2 ، 25 $^{\circ}$م) حسب المعادلة (3) :

$$ف = \frac{ك_م \times ق_أ \times كف_{م م م} \times م_{ق ق} \times م_{د ق} \times 3600}{ج \times ث \times ع} \qquad (6)$$

حيث جـ = عجلة الجاذبية الارضيـة م/ث^2 ث = كثافة المياه ك/ متر^3

ع = مقـدار الرفـع متر

م د ق = معامل القدرة المعدل حسب درجة حرارة الخلايا عند التشغيل المحسوبـه بالمعادلـة (7) ويحسب باستخدام المعادله (8)

م د ق = معامل القصـور في التوافق بين نقطـة التشغيل ونقطة اقصى قـدره

$د_ت$ = د هـ + 0,3 × ك (7)

حيث $د_ت$ = درجة حرارة الخلايا م° (4)

$د_هـ$ = درجة حرارة الهواء في الموقـع كمتوسـط شهـرى م°

$ك_م$ = معدل الاشعاع الشمسي على سطح الخلايا المائل (مليوات/ سم^2)

$$م د ق = 1 - \frac{(د_ت - 25)}{2000} \qquad (8)$$

3-4 - تحديد الحجـم الامثـل للمنظومـــــة :

وأخـيرا تتخلص خطوات الاسلوب المراد اتباعـه لتحديد الحجـم المناسب للخلايـــا المستخدمـة في ضـخ المياه حسب مواصفـات احمـال معينـة ومستوى تخزين المطلوب فـي الخطـوات التاليـــة :

(أ) تحديد الحجم الادنى للخلايا المستخدمة باستخدام كفاءة خلايا حسب القـــدرة القصـوى للخلايا المطلوبه كحد أدنـى باستخدام المعادلة التاليـــة (5) :

$$ق_ن = \frac{\text{الاستهلاك اليومي المتوسط للسنه} \times \text{الرفع}}{\text{الاشعاع المتوسط اليومي للسنه} \times \text{الكفاءة الكلية للنظام}} \qquad (9)$$

(ب) تحديد الحجم الاقصى حسب منحنى الحمـل على مدار السنه ومنحنى الاشعـــاع على مدار السنه يؤخذ الشهر الذى يحتاج لاكـبر حجـم للخلايا ٠

$$ق_ص = \frac{\text{الاستهلاك اليوم المتوسط في هذا الشهر} \times \text{الرفع}}{\text{شدة الاسعاع المتوسطة لنفس الشهر} \times \text{الكفاءة الكلية للنظام}} \qquad (10)$$

(ج) باعتبار الحد الادنى من التخزين موجود فعلا وأخذ قدرة خلايـا اكـبر بقيمـــة صغـيرة مناسبـة تضاف للحد الادنى للخلايا المطلوبة ويحسب مستوى الميــــاه في الخزان على مدار السنـه ٠

(د) بالاستمرار في الزيـادة في حجـم الخلايا يمكـن ان تصل الى حجـم خلايا بحيث يتحقـق فيـه أن الحد الادنـى للمياه يكون موجـود بالخزان على مدار السنه٠

4 - نموذج للدراسة المقترحة :

4-1- البيانات المستخدمة فى التصميم :

(أ) معلومات عن المكان :

(1) الموقع الجيزه خط عرض 30° خط طول 31°.
(2) جدول رقم (1) يمثل متوسط الاشعاع الشمسى على مدار العام وكذا متوسط درجة حرارة النهار.
(3) تتعرض المنطقة لبعض الرياح التى تحمل أتربه أثناء رياح الخماسين فى شهر ابريل.

جدول رقم (1) يبين المتوسط الشهرى لكثافة الاشعاع الشمسى ، ودرجات الحرارة المتوسطة للنهار والحمل الشهرى على مدار العام .

الشهر	كثافة الاشعاع الشمسى على السطح الافقى ك وات ساعه/م^2 .يوم (6)	متوسط درجة النهار م°	الرفع م	الاستهلاك الشهرى م^3
يناير	3,3	14,9	6	1840
فبراير	4,5	15,9	6	1680
مارس	5,7	19	6	2330
ابريل	6,6	23	6	2250
مايو	7,5	26	6	2790
يونيه	7,8	28	6	2700
يوليه	7,7	29	6	2790
اغسطس	7,2	26	6	2790
سبتمبر	6,22	27	6	2250
اكتوبر	5	25	6	2170
نوفمبر	3,55	20	6	1800
ديسمبر	3,00	17	6	1840

(ب) معلومات عن الاحمال وظروف الاستخدام :

الاحمال المفترضة للشرب وللرى حسب ما هو مبين بالجدول رقم (1).
حجم التخزين المطلوب هو 150 م^3 والحد الادنى للتخزين هو 25 م^3

جدول رقم (2) يبين شدة الاشعاع الشمسي على السطح المائل وزوايا ميل لكل شهر ومستوى المياه في الخزان على مدار العام باستخدام خلايا بقدرة 800 وات

الشهر	زاوية ميل سطح الخلايا على الافقى	متوسط شدة الاشعاع على السطح المائل	مستوى مياه في الخزان
يناير	45	5,04	26
فبراير	45	6,00	125
مارس	30	6,62	125
ابريل	30	7,2	125
مايو	15	7,73	110
يونيه	15	7,8	125
يوليه	15	7,77	125
اغسطس	15	7,40	54
سبتمبر	30	6,88	125
اكتوبر	30	5,93	125
نوفمبر	45	5,20	125
ديسمبر	45	4,76	25

(جـ) معلومات عن الانظمة المتاحة :

لا يوجد تصنيع محلي للخلايا الشمسية او طلمبات اعماق بالاحجام المناسبة. يمكن استيراد الاجزاء المختلفة من الخارج والمعلومات عن الانتاج العالمي من الخلايا والمعدات متوفره .

4-2- خطوات التصميم :

(أ) حسابات الاحمال :

من جدول رقم الخاص بالاحمال يمكن حساب الاستهلاك اليومي المتوسط على مدار السنه وهو 75 متر^3/ يوم .

أقصى حمل هو 90 متر^3 / يوم وهو متوسط شهري للشهور من مايو الى اغسطس .

أسوا ظروف التحميل تحدث في شهر ديسمبر حيث يكون الحمل 60 م^3/ يوم

ولكن شدة الاشعاع الشمسى فى نفس السهر هى 76ر4 كيلوات ساعه / م 2٠ يوميا على السطح المائل بزاوية 45°٠

(ب) حساب الحجم الادنى والاعلى :

من جدول رقم (1) نجد أن متوسط الاشعاع الشمسى السنوى هو 523ر6 كيلوات ساعه / م 2 يوميا على اسطح مختلفة الميل حسب الفصل وباستخدام المعادلة (9) فان الحد الادنى لحجم الخلايا المقابل للحمل المتوسط السنوى يكون 780 وات ٠

القدرة اللازمة لمواجهة أسوأ الظروف عند شهر ديسمبر باستخدام المعادلة (10) هى 850 وات ٠

وأخذ فى الاعتبار البيانات الخاصة بالتخزين وحده الادنى ويعمل محاولات لتخفيض حجم الخلايا بواسطة استخدام الخزان عن طريق حساب حالة التخزين شهريا على مستوى السنه وجد أن الخلايا بقدرة 800 وات هى التى يمكنها أن تقوم بمواجهة الاحمال المطلوبه تحت ظروف التخزين الموصفه والجدول رقم (2) يبين سير مستوى التخزين على مدار السنه لهذا الحجم من الخلايا ٠

والشكل رقم (1) يبين الانتاج والحمل الشهرى على مدار السنه لنفس القدره (800 وات ، كما أن الشكل رقم (2) يوضح مستوى التخزين على مدار العام ٠

5 - الاستنتاج :

5-1 - باستخدام الاسلوب المقترح فى النموذج السابق وجد ان الحجم الامثل للخلايا هو 800 وات وذلك بخلاف لو أن التصميم تم على أسوأ الظروف التى تحتاج لحجم خلايا 850 وات وهذا يوفر فى التكاليف الكلية ٠

5-2 - من الدراسة السابقة وجد ان العوامل التالية لها تأثير هام على تحديد الحجم المناسب للخلايا ٠

(أ) تغير قيمة الاشعاع الشمسى على مدار السنه وتعظيم الاستفادة منه عن طريق استخدام أنسب زوايا الميل لكل فصل ٠

(ب) تغير مستوى الاحمال على مدار العام٠

(ج) تغير درجة حرارة الجو المحيط وبالتالى درجة حرارة تشغيل الخلايا ٠

(د) استخدام قيم لكفاءة المعدات المستخدمة من واقع الخبره الحقليه ٠

Education in the field of solar energy

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Bias and prejudice, largely based on ignorance and misinformation, are preventing the spread and application of solar energy on a worldwide basis. However, in the future it will be this solar energy which can and must be the only solution to our energy and environmental problems - for it is solar energy whose availability is inexhaustible. In addition, it is the application of solar energy which can prevent combust ion, radiation and heat emission into the atmosphere. Mankind has been educated and indoctrinated to think mainly in economic terms - and herein lies our problem: for it is a fact that during the past two generations, and even today, the burning of fossil fuel (coal, oil and gas) represents the cheapest method. The damage to our environment which is caused by the emission of carbon dioxide, sulfur oxide and nitrogen oxide has been recognized by a few scientists and other some time ago: however, the suppliers of energy have tried to hush up this information - or at least to water down its impact. It has only been during the last few years that the public at large has been aware of what problems are being caused - and will be stored up for the future - through the burning of fossil fuel as well as from the use of nuclear energy. Despite all this, the problems are being minimalised by the energy industries, e.g. the oil anc gas companies as well as the electricity authorities. These enterprises, with their vested interests, which can avail themselves of huge advertising budgets, find it relatively easy to influence public opinion in their favour. This process starts by their calling into question the ecconomic viability of solar energy and ends with poli i i n` s trying to explain to the public that future generations will find it impossible to manage without nuclear energy.

Vis a vis such attitudes, the advocates and users of clean and unlimited as well as benign sources of energy have so far had little chance because their source of energy is not as saleable commodity and hence they are not represented by a lobby. To this end, we can make our con tribution by discovering and applying alternative sources of energy for heating our domestic hot water and room heating and the heating of swimming pools, als well as for use in the commercial and industrial realm. If, however, our children of future generations are to find an environment in which it is worth living it will take great efforts to replace, within a short time, this fossil energy (which, in any case, is exhaustible) and nuclear energy with environmentally-friendly and unlimited energy sources such as solar energy, wind energy, water energy or the heat of the earth. To con tribute to this effort now, we can seek and use alternative methods of heat for the preparation of domestic hot water, for heating our houses and for the heating of swimming pools, as well as for use in the industrial and commercial realms. A substitution or replacementof hitherto-used energy sources can in the future possibly be achieved by means of a worldwide hydrogen technology. One should for example, produce hydrogen in desert areas (which are not used for anything else) with the aid of solar energy and hydrogen could then be transported in pipelines or tanks to all parts of the world where it could be used to power heating and electricity installations. All these possibilities are yet virtually unknown to the population at large. The introduction and application of alternative energy which, within the course of the next two generations will be imperative in any case, is however only possible if we familiarise ourselves with this type of energy supply thoroughly now.

For this very reason, it is imperative that the idea of alternative energy sources be integrated into human learning process from the earliest stage and is then carried on from childhood into old age. Since, however, we human beings are known to react more to emotion and feelings than to reason, practical demonstrations of the possibilities will achieve their aim more rapidly and effectively than would a purely theoritical explanations. On the other hand, in certain areas, the theoretical observation of problems is unanavoidable for the further development of techniques. Basically one ought to ask that the topic of energy - and especially solar energy - be included in the education process of all children and adults. Depending on age, there are certain stages of development which are clearly mapped out. These stages of development must contain topics on solar energy. To start with, there are the following stages of development:

1. 1 - 3 years old
   The child is near his mother
2. 4 - 10 years
   The child attends primary school
3. 10 - 15 years
   The child attends secondary school
4. 15 - 18 years
   The child attends a grammar school, the upper forms of secondary school or a vocational college
5. 18 - 25 years
   Polytechnic or University
6. 25 years plus
   Taking part in courses, seminars, lectures.

Until the end of the compulsory school age, there are not many differing areas in the learning process. However, once compulsory education has ended, there are several avenues the young person could take: -

1. The young person enters an apprenticeship with a view to gaining a diploma.
2. The young person continues at school to sit his A-levels or attends a 6th Form College with a view to future attendance at university or polytechnic. Initially, the route to admission to a polytechnic or university is the attainment of A-level grades.

After completing an apprenticeship and school, further steps on the education ladder can bei sub-divided as follows:

1. The apprentice has completed his training and does not undertake any further education or training. However, if he takes this road, he will be compelled to educate himself further at various stages during his working life in order to hold down his job until he draws old-age pension.
2. The apprentice has completed his training and continues to take a diplom course in order to reach the top of his trade/craft.
3. The pupil has completed his secondary education and has attained his A-levels, He then attends a vocational school, polytechnic, technical college or university. Lately even young persons with an Abitur (A-level) have been entering into apprenticeships. Even when this training has been completed, he or she will have to attend different courses during the working life in order to keep up with the latest

and rapidly- changing developments in his/her field. The continuing education can be divided into the following areas:

1. Evening courses
2. Special seminars in his/her particular field and conferences.
3. Seminars and courses which are conducted by firms themselves for their employees.
4. Re-training from a trade/occupation which is no longer required to one that is in view of new developments.

The following again demonstrates the different stages and subdivisions and how can integrate learning into each of these:-

1. 1 - 3 years
   At this age, in addition to the usual stories which a mother tells or reads to her child, there ought to be stories about the sun. Any demonstration of technical tests at this age is not yet desirable.
2. 3 - 6 years
   The child attends a kindergarten. Sice it now plays with building blocks, one should try to incorporate elements with moving parts such as wind mills, water mills/wheals, little cars which are driven by a miniature electric motor which could be powered by a solar cell. In this way, the child will learn that movement and power can come from light and that it is not always necessary to use a battery or electrical power. There are for example solar-powered toys like boats, key rings which play a tune, solar-powered radios and so on. The power of the sun's rays is especially demonstrated by means of inflaming paper using a lens or by solar cooking.
3. 6 - 14 years
   The child attends school and in the upper forms he might attend physics lessons. In addition to toys already described earlier which can be used here also, other appliances or equipment can be used which further demonstrates to the pupil the use and application of solar energy. The pupil should learn that the output of a solar installation depends on its size; that the temperature which can be reached depends on the construction and that while producing electric current from the sun's rays, one can change the poling of the solar cell and thereby let the motor run forward or backwards. It can also be demonstrated that since sunshine ist not available at all times, one can also store solar energy.

For this, there are the following physical apparatuses:

3.1 A simple solar energy collector. It contains, for example, a thermometer and will be placed in the sun and depending on time of day and the intensity of the sun, different temperatures can be reached. In this way, one can demonstrate to the child what high temperatures can be reached by means of such a simple solar energy collector. For even today, a lot of people are convinced that temperatures over 50 to 60 degrees C cannot be reached by means of a solar apparatus. However in reality with such instruments, temperatures of over 150 degrees have been reached. A further application of solar power could be for solar-powered wrist-watches, as well as pocket calculators and radios in addition to solar driven battery chargers for small batteries which can be used in radios.

During physics lessons, the following would be suitable:

3.2 A simple solar energy collector coupled with a small heat storage vessel and an circulation pump. With the aid of this equipment it can be shown that the sunlight together with the pump can produce heat from the collector, and the heat from the solar collector can be transferred into the storage vessel and if this vessel is properly insulated, heat can even be stored for some considerable time.

Such an apparatus is shown in Figure 1 which also shows its compact construction. This apparatus consists of a solar energy collector, a storage vessel, a circulation pump, a flowmeter and two thermometers in this solar circuit as well as a thermometer in the storage vessel. With the help of an artifical source of light (or if the experiment is conducted out-of-doors with sunlight), the collector is heated and transmits, with the aid of the pump, this heat to the storage vessel. With the measuring implements one can then measure input and output temperature and with the help of the through-flow quantity/time unit, one can determine the heat output of the collector. With the help of the thermometer and time clock, one can determine the heat loss of the storage vessel. Different collectors can be used for different purposes: for the heating of swimming pools, one could use non-glazed collectors and for the preparation of domestic hot water in sunny countries, one could use black-lacquered glass panels. For the preparation of hot water in areas with less sunshine, one should use absorbers which have been selectively

coated and are then covered with highly-transparent glass. All these possibilities can be explored with the aid of this equipment above.

The variable parameters are:
1. Absorber black, absorber selective
2. With or without insulation
3. 1 or 2 panels of glass
4. Normal or highly-transparent glass.

Assuming one measures the heat emission of the collector under the same light conditions and the identical flow-through quantities per time unit and the time it takes to heat the storage vessel, these differences can be demonstraed clearly.Figure 2 shows the different results of measurements for a collector containing 1 or 2 panels. This apparatus is useful for demonstration to younger children and also can be used to show to older children the different methods of construction.

In order to demonstrate how electric current can be produced from sunlight, the equipment pictured in Fig. 3 is suitable. This apparatus consists of a solar cell which has on its reverse side a cooling and heating panel. This cooling and heating panel can reach various temperatures with the aid of a thermostat. The solar cell is connected to a variable resistor and contains 2 measuring gauges for the measuring of tension and flow of current. With the aid of the variable resistor, one can simulate different users and the typical diagramm of the solar cell can be demonstrated for different intensities of sunlight and different temperatures thereby reached.
For the demonstration of producing mechanical energy from solar power, one can use a combination of a concentration mirror and a Sterling motor (Fig.5)

4. 15 - 20 years
One can use the above-mentioned equipment for use in schools and for vocational training at places of work, the only difference being that the experiments will be executed in a more detailed and exact manner. In addition teachers could conduct special courses whereby, for example, a solar energy collector could be built from individual parts and could be equipped with a small storage vessel, a gauge and a circulation pump. Here we have a small solar heating installation. In physics class one should also demonstrate the production of hydrogen with the aid of a simple experiment. A apparatus to split water into hydrogen and oxigen, which is based on the electrolysis of water, is

powered by a small solar cell. The hydrogen and oxigen obtained could be stored in small gasometers, can be combined again later and will demonstrate the combination of hydrogen and oxigen by burning to make water.

In order to get exact evaluations of all experiments, the intensity of the light source must be known. The apparatus which transforms light into other forms energy has to be lighted evenly. One can achieve this in the laboratory by means of a quartz lamp which lights an even space or one can achieve this in natural sunlight. In order to arri ve at thé exact intensity of the insolation, one uses light meters. Universities which conduct more exact experiments use Pyranometers, used by meterological stations. For simple experiments one can use a so-called heliometer. (Fig. 7). By means of the heliometer it can be demonstrated how the intensity of the sun can fluctuate considerable. One can show fluctuations originated by humidity in the atmosphere which pass the sun. With the naked eye, one can frequently not even perceive theses fluctuations, while the measuring gauge shows them clearly. Additional characteristics which influence the planning of solar installations very strongly are, for example, other liquids used in solar installations - liquids, whose properties differ strongly from those of water. Theses liquids should not be allowed to freeze in winter, and when the solar installation is switched off in the summer must not overheat. These liquids, mostly based on glycol, have a much higher viscosity than water. Therefore the output of a circulation pump is much lower using these liquids than for using water and the diagrams supplied by the manufacturers base on using water. The flow resistance of these liquids is also much higher in pipes than it would be were water is used. The usual literature which describes the planning of pipes and pumping systems hardly mentions these characteristics which differ so greatly from those of water. However, engineers who build solar installations must be aware of the above. In order to demonstrate the problems which are specific to solar heating installations, and to produce diagrams for pumps as well as for pipes, the measuringapparatus (Fig. 8) has been developed. The different liquids, with their different viscosities, can be used in this apparatus. It contains a small heat resistor which can heat the liquid to various temperatures. This is therefore necessary because the viscosity of these liquids differs greatly depending on the temperature - which is not the case with water.

To this apparatus different pumps for measuring can be added. One could also add to the system valves etc. for which the flow-through resistance could be measured. The flow-through can be measured with a flowmeter which is simlar to a water meter, and a stop watch. This method is the cheapest and is also very exact. In front of and at the rear of the apparatus for which the flow-through has to be measured, the re is a pressure gauge. This gauge is connected to a pressure meter andshows there the pressure difference on an analog or digital display.

In order to show that liquid expands in rising temperatures and that pressure increases, the apparatus can be equipped with 2 individual analogous pressure gauges. Figure 9 shows the diagram of a pump which is usual in solar installations and can be used with water as well as with a highly concentrated glycol which reaches the boiling temperature of 180 degrees C at 2 bar over-pressure . Figure 10 shows the diagram:loss of pressure as a function of the flow-through for copper piping for water as well as for the highly concentrated glycol.

For tradesmen and people who install solar heating installations, the manufactures offer courses and seminars. During these courses the different areas of application and switching mechanisms are explained and possibly even demonstrated on practical models. In addition, each individual component of the solar installation is explained thoroughly, in theoretical and practical terms. Within this belongs also the explanation of how the different liquids used to differ in their properties and reactions. Problems occur frequently when a heating specialist who installs a heating system is asked by his customer to install pipes for a possible future installation of or conversion to solar energy. These pipes are mainly intended for water and later on when glycol is required to run the system, these pipes prove much too narrow. These problems can be prevented if there is proper information and training. Another problem lies in the fact that many people are convinced that Northern Europe does not have sufficient sunshine. In reality the difference between the summer (sunshine) half-year in Northern Europe expressed in hours of sun is only 20 to 30 per cent less that it is in, for example, North Africa. Taken on an annual basis, it can be seen that even the "sun-richest" area of the world has only 2.4 times as much sun energy as Northern Europe. An additional problem is that solar energy is often linked to the idea of generation of electric current. Since, however, the energy use of industrial nations can be broken down into 80 per cent for energy for heating and only 20 per cent for electrical energy, the potential

for saving on the heating energy is much greater. In addition, installations for the generation of heat from solar energy are even in this day and age relatively cheap where as the generation of electrical power from solar energy is still relatively expensive and, to a large extent, still in its development stage. The idea that solar energy is primarily used for the generating of electricity is, for example in the German Federal Republic, fostered by the electricity generating boards. They try to divert attention from the fact that it is nearly within everyone s financial reach to afford a solar heating installation in order to heat their domestic water, their houses or their swimming pools. Solar-powered electricity installations are not yet feasible because of the high cost. The utility companies (gas, coal and electricity) try to influence the general public in thinking that solar energy is not aconomical by concentrating their information on the production of electricity (which, it is true, is still expensive and in its early stages) and neglect to inform the public of how solar energy can be used for heating. In this way they ensure that people continue to buy their products (coal, oil, gas).

If solar energy were introduced more widely (bases on adequate and true information), the utility companies would suffer a tremendous loss in their turnover and hence profits.

A family could save 1 000 litre of heating oil or 1 000 cubic metres of gas or 2 000 kWh of electricity if they were to switch to solar heating only for their domestic water.

This would indeed represent a loss to the utility companies.

One has to counter strongly this spreading of false information regarding solar energy. To achieve this, a visit to solar installations which have been operational for some time can be arranged. People who have solar heating installations in Germany primarily installed these because of their concern for the environment. They consider the economic reasoning as a secondary factor. They maintain the motto: What's the use for saving money now if we have to spend umpteen times as much later on in order to try to repair an environment which has been spoiled. These people will be very pleased to show their installations to interested parties and to exchange their ideas and experiences. Visits of this nature should be arranged by schools and by firms for their apprentices.

The consequential incorporation of solar technology and the application of solar energy into education can therefore make a great contribution of the maintenance of the ecological equilibrim of our planet.

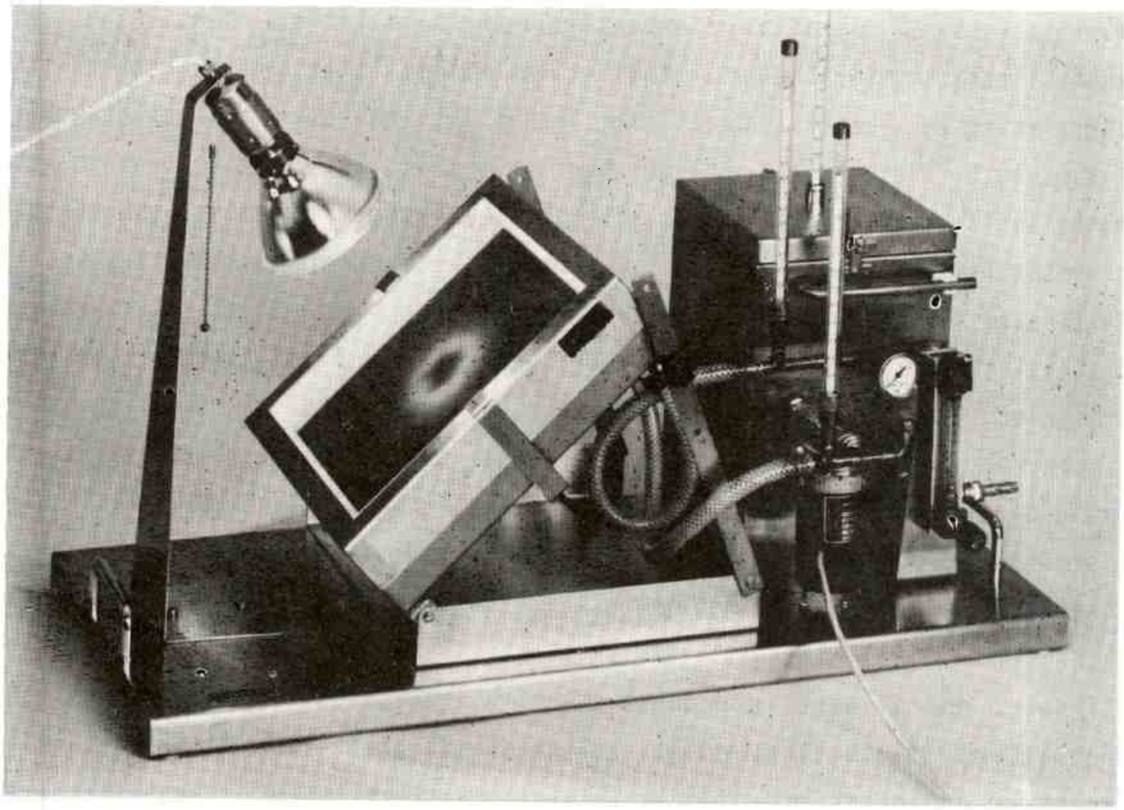

Figure 1

Solar- thermal demonstration system

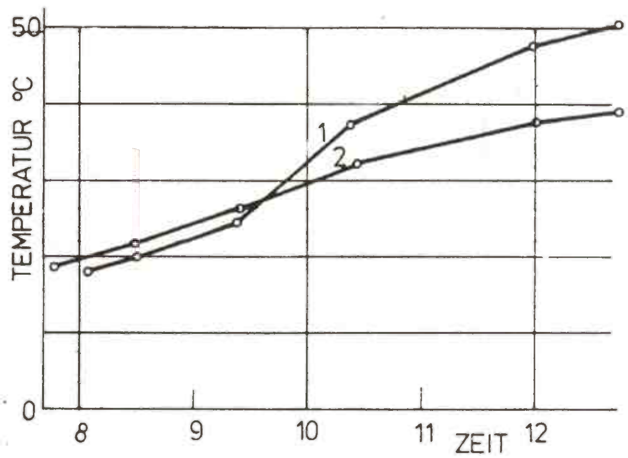

Figure 2

Experimental results from solar thermal demonstration system

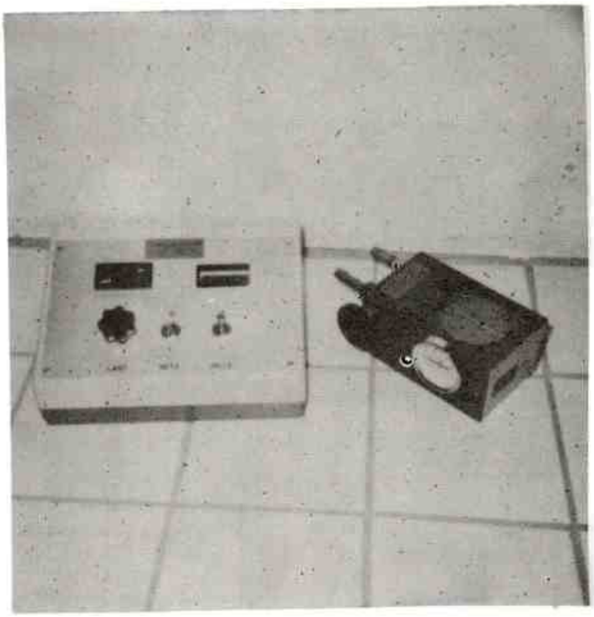

Figure 3
Photovoltaic demonstration system

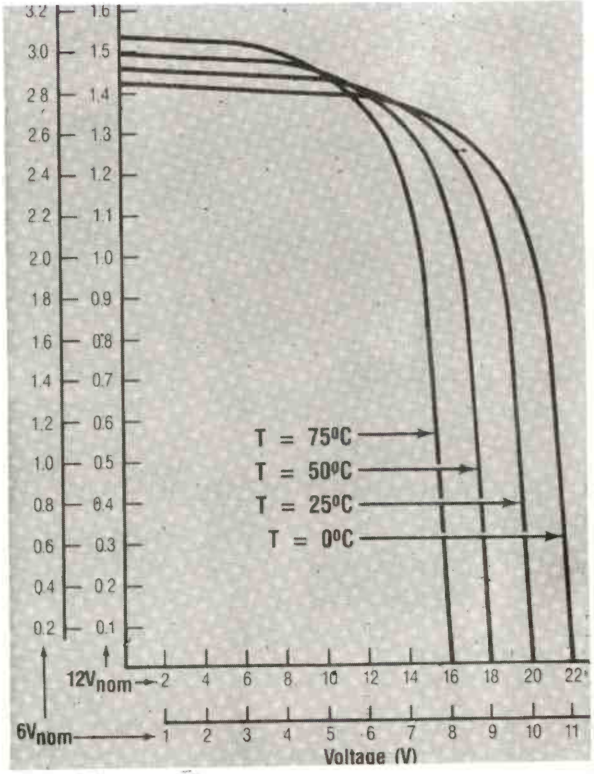

Figure 4
Typical characteristics of a photovoltaic panel (Solarex)

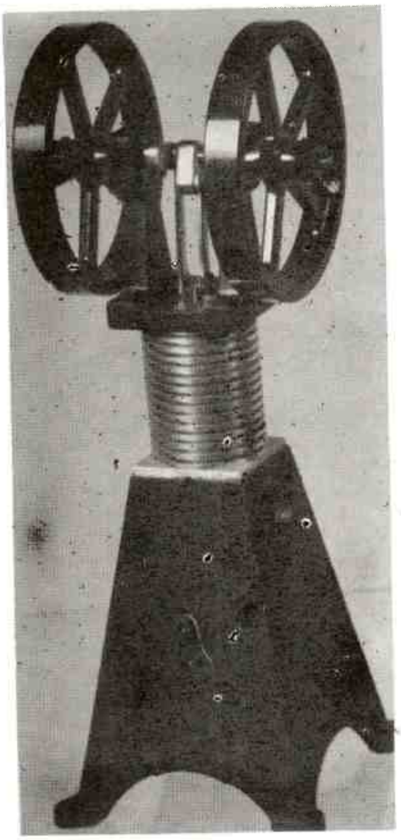

Figure 5
Stirling engine

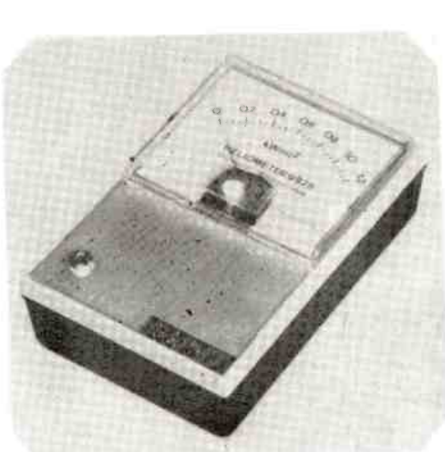

Figure 7
Pocket heliometer

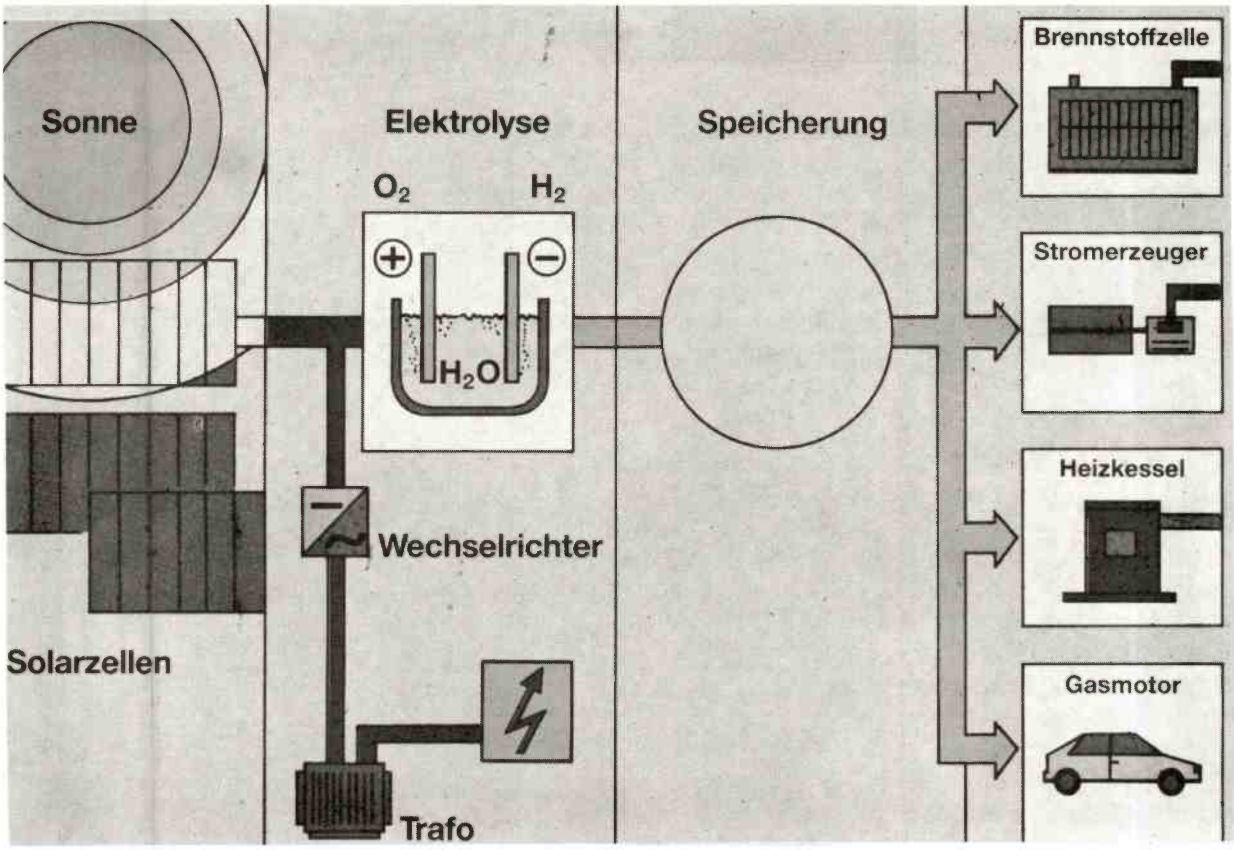

Figure 6
Solar - hydrogen - economy

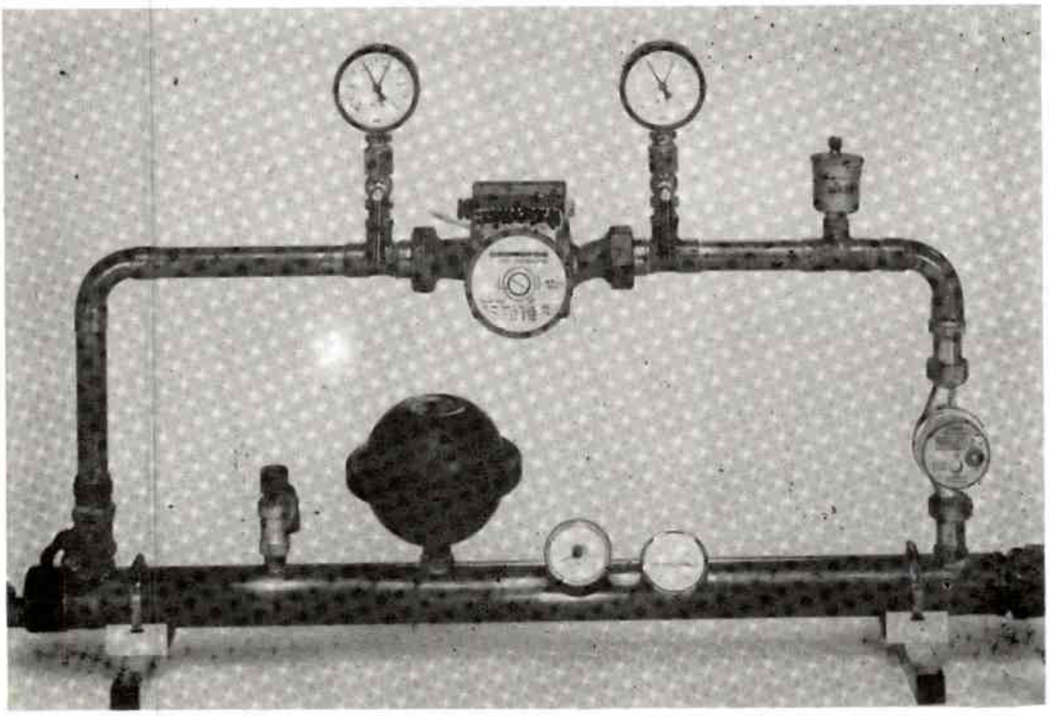

Figure 8
Circulation pump test apparatus

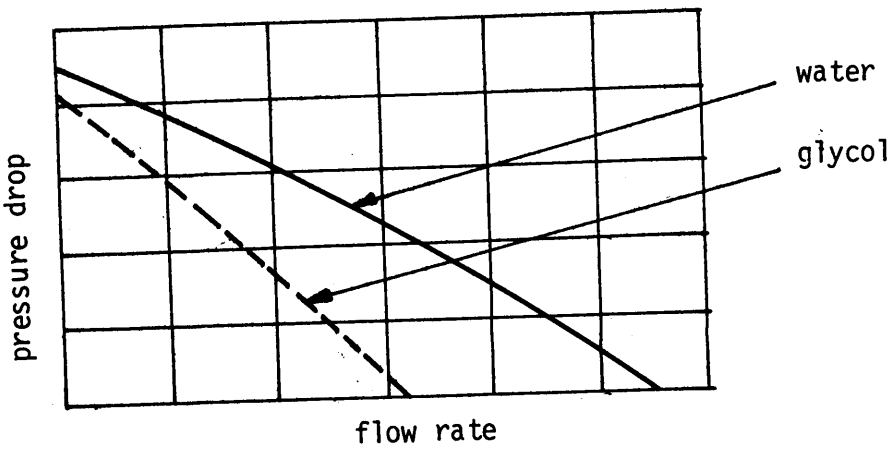

Figure 9
Typical circulation pump diagram for different fluids

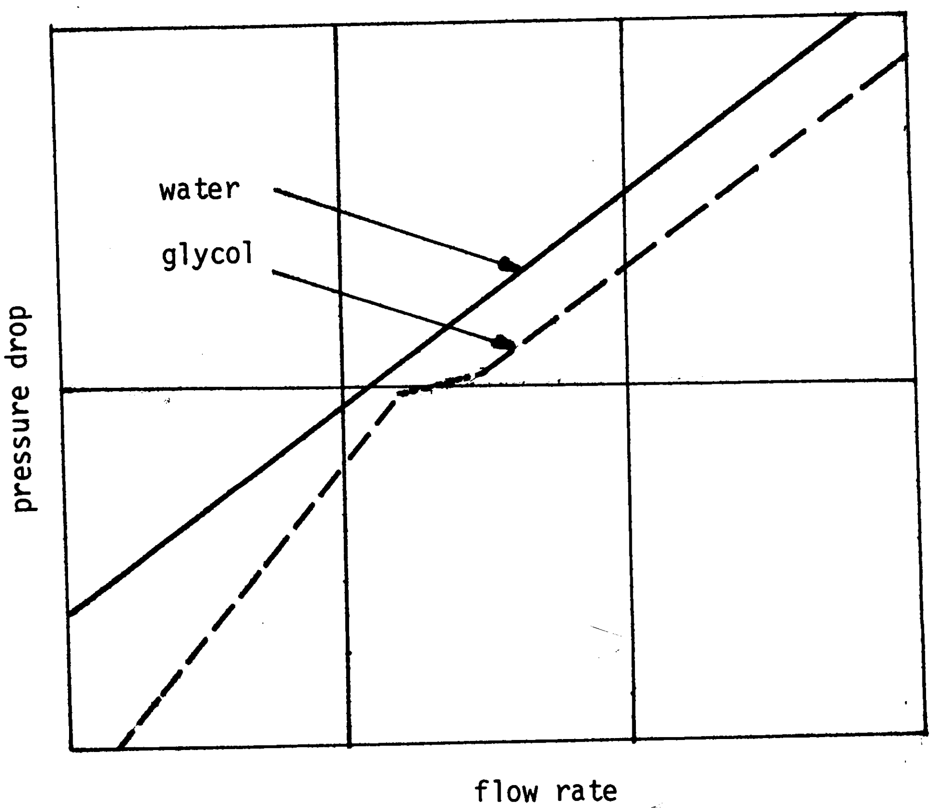

Figure 10
Typical flow through diagram for pipes and different fluids

PART 3

NUCLEAR ENERGY

THE PROPER DOSES DETERMINATION FOR POTATO (UP TO DATE) VARIETY CULTIVATED IN JAMAHIRIYA USING Co-60 SOURCE

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We aimed by this study to determine the best dose which have the excellent result and low effects on the organo-leptic, and chemical constituents using Gamma-ray emitted from Cobalt-60 as a radiation source.

The samples were irradiated with different doses, the 0.10 K Gy as a proper dose was obtained which inhibit the sprouting in potatoes (up-to-date) variety and can keep this variety in the normal storage conditions for more than 6 months with very low losses not exceeding 15% and with no significant difference in Vitamin C content and sugars (reducing and non-reducing sugars).

أ) مقدمـــــــــــــــة :-

خلال السنوات الاخيرة بدأت الاحصائيات والبيانات تشهد ارتفاعـــــا ملحوظا فى زيادة الانتاج من محصولى البصل والبطاطس فى الجماهيريـــــة نتيجه للتقدم التقنى واستخدام الميكنه الزراعيه واتباع الاساليب الحديثه فى زيادة الانتاج وهذه الزياده فى الانتاج تؤدى بنا الى التفكير جديـــا فى ايجاد احسن الطرق وانسبها لحفظ الانتاج وصولاً الى مرحلة التصديـــر بعد اشباع حاجات المواطن سيما وان الاقبال عليها متزايد فى جميـــع دول العالم لما تحتويه هذه السلع من عناصر غذائيه تميزها عن غيرهـــا وكذلك تمكننا من الوصول الى تأسيس صناعات اخرى تقوم على استخـدام هذه المادة كتصنيع شرائح البطاطس وغيرهـــا ...

وقد استخدم الاشعاع فى أغلب دول العالم بغرض منع الانبات والتعفـــن والتقليل من الخسائر اثناء التخزين الناجمه عن بعض الامراض البكتيريـه والفطريه والانبات والانكماش الذى ينشأ عن الفقد فى المحتوى الرطوبـــى اثناء فترة التخزيـــــــن .

ففى اليابان تتم معاملة البطاطس بالاشعاع لغرض زيادة وتمديد فـــترة التخزين لمدة ٨ أشهر على درجة حرارة الغرفه بعد الجمع لمواجهـــــة الاحتياجات الفعليه للسوق من هذا المحصول وقد وجد انه بالامكان الحصول على هذا الهدف بتشعيع البطاطس بجرعات تتراوح بين ٧ كيلـــو راد ١٥ كيلوراد اثناء مرحلة الكمون بينما يحتاج الى زيادة هذه الجرعـــات فى اخر تلك الفترة (٣) حيث ان هناك العديد من الخسائر اثناء التخزين وذلك نتيجه لنمو بعض البكتيريا والفطريات المسببه للتعفن وبعـــض الامراض وكذلك الانبات والانكمـاش وكمساهمه فى حل مشاكل التخزيـــن لهذه السلعه فى الجماهيرية بالاضافه الى زيادة المعلومات المجمعه دوليـــا فقد تركز الهدف للعمل فى هذه الرحلة على استخدام الاشعاع فى حفـــظ البطاطس وزيادة السعه التخزينيه لهذا المحصول المهم والمنتج بالجماهيريـه بكميات هائله والتقليل من الفاقد رغبه فى الوصول الى مرحلة الاكتفـــاء الذاتى والتصدير للخارج وقد تكثف العمل خلال المدة على دراسة تأثير جرعات مختلفه من اشعة جاما المنبعثه من المصدر الاشعاعى الكوبلت ٦٠ الموجود بمعامل الكيمياء الاشعاعية بمركز البحوث النووية التابع لمؤسسة الطاقة الذرية بقصد منع الانبات والتعفن وقد تمت دراسة تأثير الاشعاع على عدة متغيرات طبيعيه وكيميائيه والتى تنصح الوكالة الدوليه للطاقـــة الذرية بمتابعتها اثناء البحث والدراسة والتى غالبا ماتكون عوامـــل متغيره نتيجة لاختلافها بين الاصناف قيد الدراسة وتباين الظـــــروف البيئيه لكل بلد وتشمل هذه الدراسة التغيرات فى الصفات الحسيه مثـــل الفقد فى الوزن ونسبة الانبات ونسبة التعفن وكذلك شملت الدراسة معرفة التغيرات فى بعض المكونات الكيميائيه كتأثير الاشعاع على المحتـــوى من السكريات المختزله ومن السكروز ومن حمض الاسكوربيك (فيتامين ج)

كما اشتمل العمل فى بداية هذه المرحلة على تصنيف وتوزيع العينــات ومعايرة وحدة الكوبلت بغرض الحصول على جرعات اشعاعية دقيقــة ومؤكدة وذلك باستخدام (Frick solution) وبعدها وضع التصميــم التجريبى للتجربـــة .

٢) العمل التجريبــى :-

- العينات وطرق التحاليل المتبعــة :

- البطاطـــس :

تم شراء عينات البطاطس صنف (up to date) من احد المنتجين بمنطقة سيدى السائح بطرابلس وذلك بتاريخ ١٩!١٢!١٩٨٤م والتى قد غرسهــا بتاريخ ٢٣!٩!١٩٨٤م وجمعها بتاريخ ١٨!١٢!١٩٨٤م وقد اقر المنتج بـأن درنات البطاطس المباعة لم يتم معاملتها باى نوع من المواد الكيميائيــه وذلك لمنع الانبات فيها والتقليل من الاصابه بالعفن وقد تم فرز العينات بمركز البحوث النووية بإختلاف أحجامها بمعدل ٤٥كجم ثم بعد ذلك قــم تخزينها في درجة حرارة الغرفة بانتظار تشعيعها بعد أن قسمت الــي ٥ معاملات وكل معاملة تحتوي علي ٤ مكررات بغرض دراسة التغييــرات الكيميائية والفيزيائية التى تحدث بعد التشعيع ..

- التشعيـــــع :-

بعد المعايرة التى اجريت على وحدة الكوبلت ٦٠ وضبط الجرعة الاشعاعيه المنبعثه من المصدر المشع الكوبلت ٦٠ (النوع التجريبى) والــذى صنع بروسيا وورد لمعامل الكيمياء الاشعاعية بقوة ابتدائيه قدرهــا ٥٠٠ر١٦ كورى ويبلغ حجم حجرة التشعيع ٢ر٤×٣٢٠متر مكعب وحــيث ان شكل حجرة التشعيع اسطوانى ذات القطر ١٥سم والارتفاع ٢٤ســم فقد استخدم اناء زجاجى اسطوانى سعة واحد لتر وقد تم التشعيع علــى فترات وأعطيت الجراعات التاليه لكل المعاملات ٥٠و٨٠و٠٠ و١٠٠و١٥٠و٠ كيلو جرى بالاضافه الى العينه المقارنه صفر كيلوجرى .

ونظراً لصغر حجم حجرة التشعيع وكثرة العينات المراد تشعيعها فقــد استمر التشعيع مدة ٣ اسابيع بواقع سته ساعات لكل يوم عمل .

التخزيــــــن :-

تمت عملية التخزين فى أحد المعامل بالقسم وهو عباره عن حجرة مساحتهــا ٢٠ متر مربع تقريباً مكيفه تكيفاً مركزياً يتم التحكم فى درجة حرارتهــا حسب الرغبه وكانت درجة الحراره اثناء التخزين ٢٥ درجة مئويــــة وكانت درجة الرطوبه النسبة من ٥٥-٨٠٪ حيث وضعت الصناديق المحتويــة على العينات فى ترتيب عمودى وتم تغطيتها بورق مقوى لحجب الاضــاءه المسببه فى اخضرار الدرنات .

التحاليل الكيمياثيـــــــه :-

تمت عملية التحاليل الكيميائيه لغرض تقييم العينات ومعرفة تأثير الاشعاع والتخزين على فيتامين (ج) والتأثير على السكريات المختزله وقد تم اتباع الطرق الاتيه فى التحليل .

الفقد فى الـــــــــوزن :-

تمت عملية تعين الفقد فى الوزن الابتدائى باستخدام ميزان (Sartoris) وذلك بتسجيل الوزن الابتدائى للعينات عند بداية التخزين وبمتابعـــــــة تسجيل وزن الدرنات الصالحه للتسويق وكذلك عددها واستبعاد الدرنـــــات التى يظهرفيها الإنبات وكل درنه يزيد فيها نمؤ البرعم على 1سم تستبعد كذلك الدرنات المتعفنه ويؤخذ عددها ووزنها علماً بأن الدرنات المنبته والمتعفنه فى آن واحد تحسب على انه منبته .

النتائج

نسبة الفقد فى الوزن :-

من الشكل رقم (١) نلاحظ ان نسبة الفقد فى الوزن زادت فى العينــــــــة المقارنه بشكل ملحوظ منذ الاسبوع الاول من اجراء التجربه وبينما استمرت المعاملة ٠٥ر٠ كيلوجرى فى تزايد بسيط حتى الاسبوع الرابع وبلغــــــــت نسبة الفقد فى الوزن فى الاسبوع الثامن اما بالنسبه للمعاملة ٠٨ر٠ كيلوجرى وجد ان الفقد فى الوزن بدا من الاسبوع الرابع حتى وصل فى الاسبوع الثالث عشر الى مايقارب ٢٥٪ ثم استمر الفقد بشكل ملحوظ حتى وصـــــــل الى ٥٠٪ فى الاسبوع الثالث عشر اما المعاملاتان ١٠ر٠، ١٥ر٠ كيلوجرى كانت أقل من ١٠٪ .

نسبة الانبـــــــات :-

من الشكل رقم ٣ نلاحظ ان نسبة الانبات فى المعاملة صفر كيلوجــــــرى (العينـــة المقارنه) زادت بسرعة خلال الاسبوع الاول من اجراء التجربـــه فبلغت اكثر من ٩٠٪ فى الاسبوع الثامن بينما قاومت المعاملة ٠٥ر٠ قليـــلا حتى الاسبوع الرابع بعدها ارتفعت نسبة الانبات حتى اقتربت من العينـه المقارنه بالمعاملة ٠٨ر٠ كيلوجرى فظهرت فيها نسبة الانبات بعد الاسبوع الرابع واصبحت فى تزايد ملحوظ حتى بلغت مايقارب من ٢٥٪ فى الاسبوع الثامن عشر اما المعاملتين ١٠ر٠ و١٥ر٠ كيلو جرى فلم يظهر فيها اية نسبه انبات مع العلم بأن الدرنات التى وجدت منبته ومتعفنه فى آن واحـــــد اعتبرت على اساس انها منبته .

نسبة التعفـــــــــن :-

من الشكل رقم ٣ نلاحظ ان نسبة التعفن فى جميع المعاملات لاتوجد حتـــى الاسبوع الثالث عشر بعد ذلك ظهرت نسبة التعفن فى المعاملات المشععــه على العكس من المعاملة التى لم تشعع (العينه المقارنه) وقد يعزى هـذا الاختلاف الى ان الاشعاع قد يضعف قدرة خلايا بعض الاصناف علـــــــى

افراز مادة (Phyto-alxine) لزيادة المقاومة الحيوية الدرنات عند مهاجمة بعض الفطريات لدرنات الطاطس ٠

- حمض الاسكوربيك (فيتامين ج) :-

من الشكل رقم ٤ نلاحظ ان المعاملة صفر كيلوجرى والمعاملة ٠٥ر٠ كيلوجرى لم يستكمل العينات حتى نهاية فترة التخزين وذلك راجع الى تلف المعاملتان نتيجة للانبات والتعفن معاً ونلاحظ ايضا النقص الواضح فى كمية حمض الاسكوربيك فى المعاملة صفر كيلوجرى خلال الاربع اسابيع الاولى بينما ارتفع خلال الفترة مابين الاسبوع الرابع والاسبوع الثامن وبعدها بدأ فى الهبوط تدريجياً حتى الاسبوع الثالث عشر بينما يلاحظ بأن هبوط كمية حمض الاسكوربيك فى المعاملة ٠٥ر٠ كيلوجرى تدريجى حتى نهاية المرحلة والفرق ليس معنوياً بالنسبه لتأثير الاشعاع اما بالنسبه للمعاملة ٠٨ر٠ كيلوجرى نلاحظ ان الفارق طفيف وان المعاملة صفر كيلو جرى سجلت انخفاظاً ملحوظا خلال الاربعة الاسابيع الاولى وبدات فى الارتفاع حتى الاسبوع الثامن وبعدها بدأت تنخفض كمية حمض الاسكوربيك تدريجيا اما المعاملة ٠٨ر٠ كيلوجرى فقد اظهرت انخفاظاً شديداً فى مدة الثمانيه اسابيع الاولى وبدات فى الارتفاع حتى الاسبوع الثالث عشر وبعدها بدأت فى الانخفاض البسيط تدريجيا ونلاحظ من الشكل ايضا ان المعاملة ١٠ر٠ كيلوجرى سجلت انخفاظا فى كمية حمض الاسكوربيك فى الفترة الاولى حتى الاسبوع الرابع ثم استمرت كميّة ثابته من الاسبوع الرابع حتى الاسبوع الثالث عشر بعدها بدات فى الانخفاض الطفيف ولايلاحظ اى فارق معنوى بفعل الاشعاع ولكن بفعل فترة التخزين يتضح ان هناك بعض الاختلاف فى كمية حمض الاسكوربيك اما المعاملة ١٥ر٠ فقد سجلت ايضا انخفاظا فى كمية حمض الاسكوربيك فى الفترة حتى الاسبوع الرابع ثم استمرت فى شبه ثبات حتى نهاية فترة التخزين وايضاً لايلاحظ فارق معنوى بالنسبه لتأثير الاشعاع على حمض الاسكوربيك مع مراعاة ان حمض الاسكوربيك الذى تم تعينه هو على الصور (Hydro-form) اما الصورة (Dihydro-form) لم يتم تعينها فى جميع المعاملات نتيجة لعدم توفر الامكانيات اللازمة لتعينها ٠

- السكريات المختزلة :-

من الشكل رقم ٥ يلاحظ ان المعاملة ٠٥ر٠ كيلوجرى تباين فيها الاختلاف من المعاملة صفر كيلوجرى بالنقص فى كمية السكريات المختزله خلال الاسبوع الثامن من التجربه ولم يظهر فارق معنوى فى الاسبوع الثالث عشر ويلاحظ الزيادة المستمرة فى كمية السكريات المختزله حتى الاسبوع الثامن فى المعاملات صفر و ٠٥ر٠ كيلوجرى بعد ذلك سجل هبوطاً فى كمية السكريات المختزلة فى المعاملة صفر كيلوجرى فى الاسبوع الثالث عشر ، بينما استمرت الزيادة فى السكريات المختزله بالنسبه للمعاملة ٠٥ر٠ كيلوجرى وفى المعاملة ٠٨ر٠ كيلوجرى يلاحظ الزياده فى كمية

السكريات المختزله خصوصاً بعد الاسبوع الثامن وهذه الزيادة ترجع الـى مدة التخزين ولم يظهر اى فارق معنوى فى بداية التجربه بين المعامـلات المشععه والغير مشععه ، اما بخصوص المعاملة ١٠ر٠ كيلوجرى فيلاحـظ ان هناك فارق بينها وبين المعاملة صفر كيلوجرى (العينه المقارنـه) فى كمية السكريات المختزله فى الاسبوع الاول والاسبوع الرابع امـا فى الاسبوع الثامن فلم يسجل اى فارق معنوى بينهما ، بينما سجل انخفاضا بسيطا يوازى تقريبا الانخفاض المسجل فى العينه المقارنه عند الاسبـوع الثالث عشر بينما تسجل المعاملة ١٠ر٠ كيلوجرى ارتفاعا ملحوظا فى كمية السكريات المختزله فى الاسبوع الثامن عشر اما المعاملة ١٥ر كيلوجرى فإن كمية السكريات المختزلة تفوق الى حدما المعاملة ١٠ر٠ كيلوجـرى فى مدة الثمانى اسابيع الاولى حيث زادت كمية السكريات المختزلـة وفى الاسبوع الثالث عشر هبطت هذه الكمية الى مستوى يقارب المعاملـة صفر كيلوجرى وعادت الى الارتفاع فى مدة الاسبوع الثامن عشر .

الاستنـتـاج :-

ان الاشعاع له اثر كبير وواضح على انقاص الفقد فى كمية المـادة المعاملة والصالحه للتسويـق .

ان الاشعاع له تاثير ايجابى فى منع الانبات فى البطاطس صنـف (Up to date) وان هذا التأثير له مردوده فى زيادة نسبة الجـزء الصالـح للتسويـق .

ان الجرعة الاشعاعية ١٠ر٠ كيلوجرى يمكن ان تكون انسب الجرعـات الاشعاعية لصنف البطاطـس (Up to date) .

ان الاشعاع قد يؤثر على زيادة نسبة التعفن عند نهاية مدة التخزيـن ولكن هذه الزيادة لاتعتبر مؤثرة اذا ما قورنت بنسبة الفقد الذى قـد يحدث عند اتباع بعض اساليب الحفظ الاخـرى .

يمكننا حفظ البطاطس بالجرعة المذكورة سابقاً لمدة سبعة اشهر بدايـة من تاريخ الجمع دون ان تتعدى نسبة الفقد فى الوزن الصالح للتسويق ٥٠٪ .

ان الاشعاع لايؤثر على المحتوى الغذائى للبطاطس فلقد تم تحليل العينه ووجد انه لايوجد اى تأثير معنوى بالنسبه لحمض الاسكوربيك والسكريات المختزله والسكروز علماً بأن هذه العناصر تعتبر من اهم العناصر الغذائيه فى البطاطس والاكثر تاثراً بالاشـعاع .

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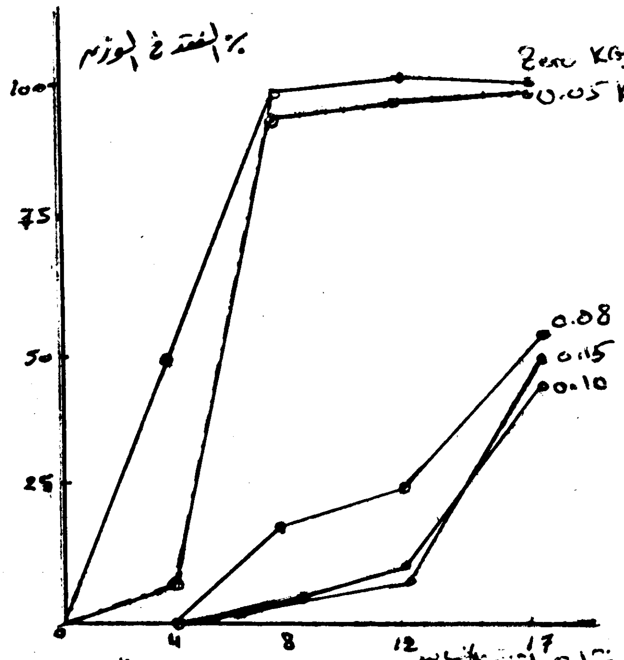
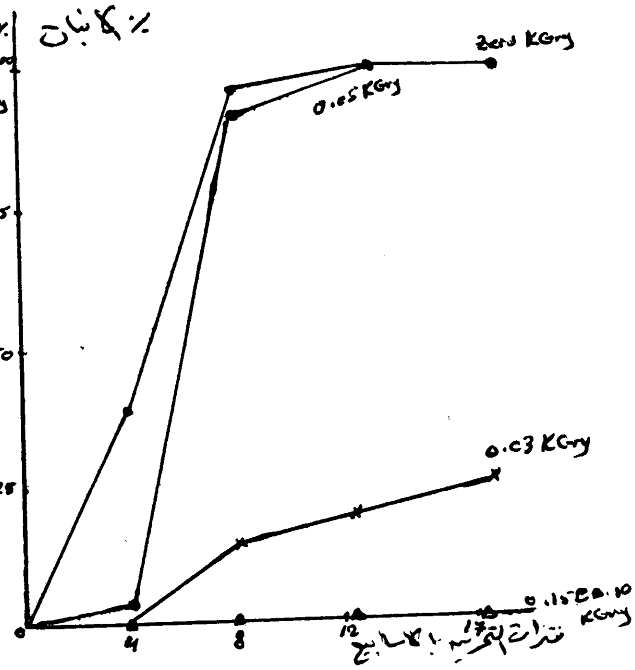
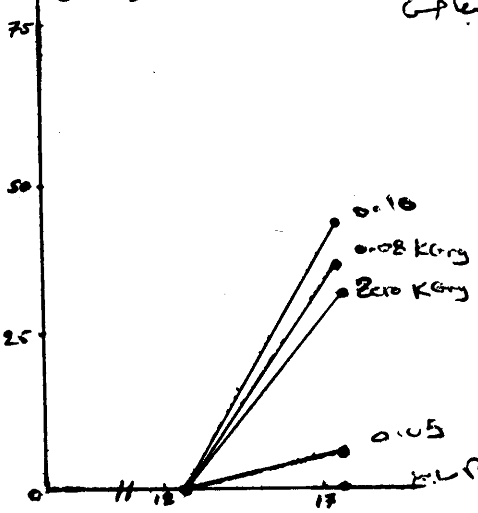


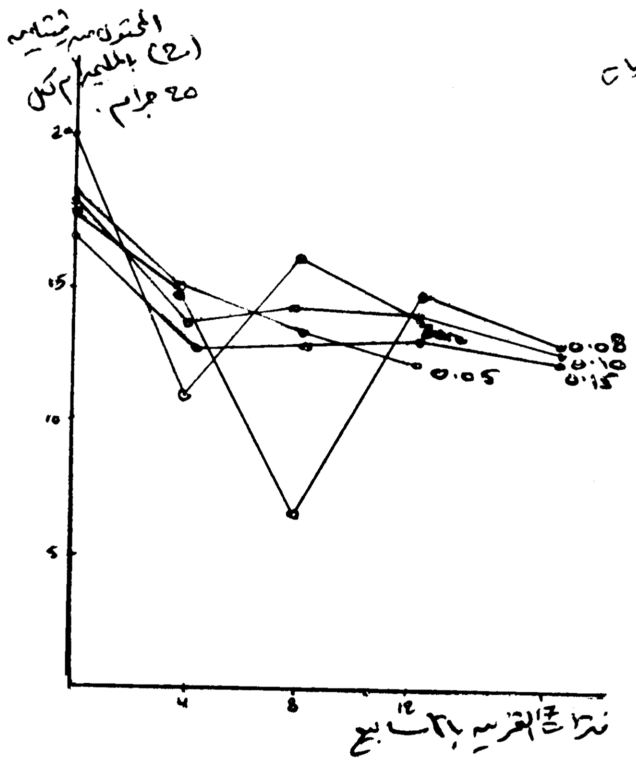
رسم يوضح نسبة الفقد في الوزن في عينات البطاطس حتى up to date (1)



شكل يوضح نسبة الإنبات في عينات البطاطس حتى up to date (2)

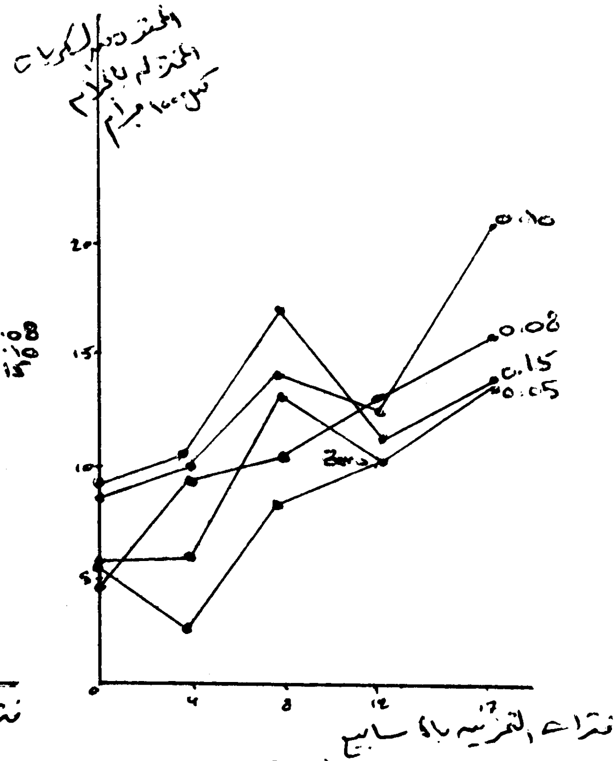


شكل يوضح نسبة التعفن في عينات البطاطس حتى up to date (3)



(4)

شكل يوضح العلاقة بين المحتوى من حمض الاسكوربيك بالمليجرام لكل جرام وفترات التخزين بالاسابيع في خيار المعاملات صنف up to date



(5)

رسم يوضح كمية السكريات المختزلة في خيار المعاملات صنف up to date

"CALCULATION OF THE FISSION PRODUCTS ACTIVITY RELEASE RATE TO THE ENVIRONMENT FROM A NUCLEAR POWER PLANT FOLLOWING A LOSS OF COOLANT ACCIDENT"

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ABSTRACT:

An exponential release model has been developed to calculate the fission products activity release rate to the environment from different barriers of a nuclear power plant. The reactor barriers considered are: (1) The primary system (2) The primary containment and (3) The secondary containment. Using this model, calculations have been performed to estimate the release rate of the two important fission products I-135 and Xe-135 to the atmosphere from the different barriers leaking at different rates. Results suggest that the use of a secondary containment highly reduces the release rate of the radioactivity to the environment.

1. INTRODUCTION:

Nuclear plants emit small amounts of radioactivity, mostly fission product gases, during their normal operation. They may release considerably more radioactivity during the course of an accident. In order to evaluate (a) The environmental impact of the normally operating plant, (b) to assure this is within acceptable standards and (c) to ascertain the radiological consequences of reactor accidents, it is necessary to be able to calculate the release rate of the radioactivity and the doses to the public from such releases.

The processes involved in the release and transport of radioactivity under hypothetical accident conditions are extremely complex. It appears that only limited data of uncertain pertinence are available(1-8). Most of the calculations assume that the radioisotopes are released instantaneously from the core following an accident. This conservative model will give an estimate of the radioactivity release rates which will never be exceeded by the actual release rates.

However, this picture of the release rate of the fission product is far from the real situation and over conservative. A more realistic model presented in section 2 has been used to calculate the fission products activity release rate of the two important isotopes I-135 and Xe-135 to the environment from the different barriers of a pressureized water reactor following a loss of coolant accident. These two isotopes are present in large quantities and are highly volatile. In addition, iodine is biologically potent because it concentrates in the thyroid. The activity equation necessary to calculate the quantity of a given fission product isotope is presented in section 3.

The results of the calculations performed are presented in section 4.

Conclusions drawn from the analysis of the results are given in section 5.

2. DEVELOPMENT OF THE EXPONENTIAL MODEL:

Let us assume that an accident takes place at time $t=0$ and that a time $t=t_0$ has elapsed from the start of the accident to initial fuel element failure. The primary system may be represented by the schematic diagram shown in Fig.A. Assuming that the reactor is scrammed upon the onset of the accident conditions, the build-up of any given isotope i for example will be only due to the decay of the precursors and not by direct fission. If isotope i has a precursor p, then the decay equation is

$$\frac{dN_i(t)}{dt} = \lambda_p N_p(t) - \lambda_i N_i(t), \qquad (2.1)$$

where

$N_i(t)$ and $N_p(t)$ are the total quantity of isotope i and its precursor p respectively at time t,

λ_i and λ_p are the decay constant of the isotope i and its precursor p respectively.

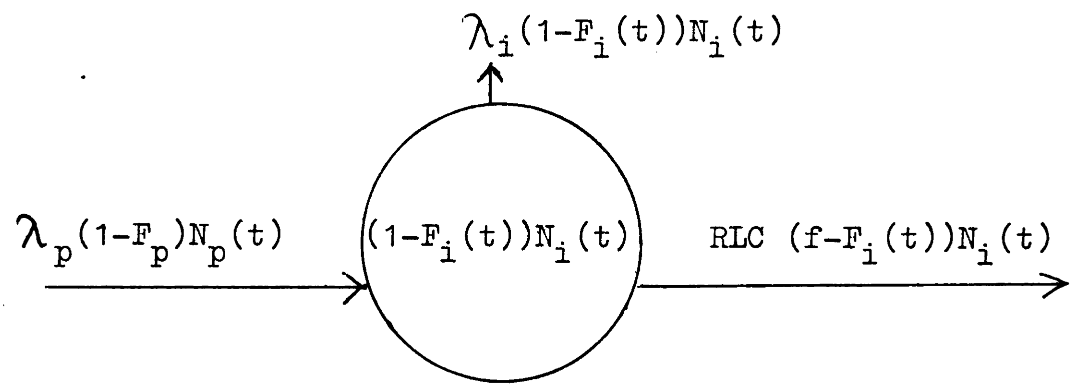

Fig. A. Primary System.

Not all radioactivity released from the reactor core during hypothetical accident conditions would be available for leakage to the atmosphere. Activity released in particulate form can be at least partially trapped in appropriate filters. Other volatalized components, such as iodine, can be partially removed by adsorption on charcoal or other high-active surface materials. Water soluble elements as well as particulates can be "Knocked down" by water sprays. Only the inert noble gases would be unaffected by such systems and would be fully available for release to the atmosphere.

Let us assume that at time t the fractional release of isotope i from the primary barrier (ceramic uranium dioxide and Zircaloy fuel rod cladding) is f where f has values from o to 1. The value f=1 corresponds to instantaneous release of isotope i. The fraction of the total quantity of isotope i that has escaped from the core as gas may be notated as $F_i(t)$ and the corresponding fraction of the precursor is $F_p(t)$.[1] Thus, the quantity of isotope i held up in the primary at time t is $(1-F_i(t))N_i(t)$ and the quantity of isotope i leaked from the primary at time t is;

$$RLC \times (f - F_i(t))\, N_i(t)$$

where RLC is the release constant per unit time.

By setting up the material balance using Fig.A, we get

$$\frac{d}{dt}\left[(1 - F_i(t))\, N_i(t)\right]$$

$$= \lambda_p\,(1- F_p(t))\, N_p(t) - \lambda_i\,(1-F_i(t))\, N_i(t) - RLC\,(f - F_i(t))\, N_i(t), \qquad (2.2)$$

The rate of change of the fraction $F_i(t)$ can be obtained by differentiating the left hand side of equation (2.2) and using Eq.(2.1) and rearranging the results; that is

$$\frac{dF_i(t)}{dt} + \lambda_p\left(1 - \frac{F_p(t)}{F_i(t)}\right)(N_p(t)/N_i(t))\, F_i(t) = RLC\,(f - F_i(t)), \qquad (2.3)$$

If we assume that the precursors move in the primary system in the same manner as isotope i,

$$F_i(t) = F_p(t)$$

and Eq. (2.3) reduces to

$$\frac{dF_i(t)}{dt} = RLC\,(f - F_i(t)) \qquad (2.4)$$

Integrating Eq.(2.4) and using the initial condition,

$$F_i(t) = 0 , \qquad 0 \leq t \leq t_o \qquad (2.5)$$

We get

$$Fi(t) = f\left[1 - e^{-RLC\,(t - t_o)}\right], \quad t > t_o, \qquad (2.6)$$

The solution given by Eq. (2.6) and the initial condition given by Eq.(2.5) is called the "exponential release model".

A more conservative model called the "step model" may be obtained from Eq. (2.4) by setting $f = Fi(t)$, that is by assuming instantaneous release of isotope i from the core. The solution of Eq. (2.4) in this case using the initial condition of Eq. (2.5) is

$$\begin{aligned} F_i(t) &= 0 , && 0 \leq t \leq t_o , \\ F_i(t) &= f , && t > t_o , \end{aligned} \qquad (2.7)$$

Since the amount of radioisotope i that leaks to the contrainment is determined, the primary containment system may be represented by the schematic diagram shown in Fig. B. Where the parameters are defined as follows:

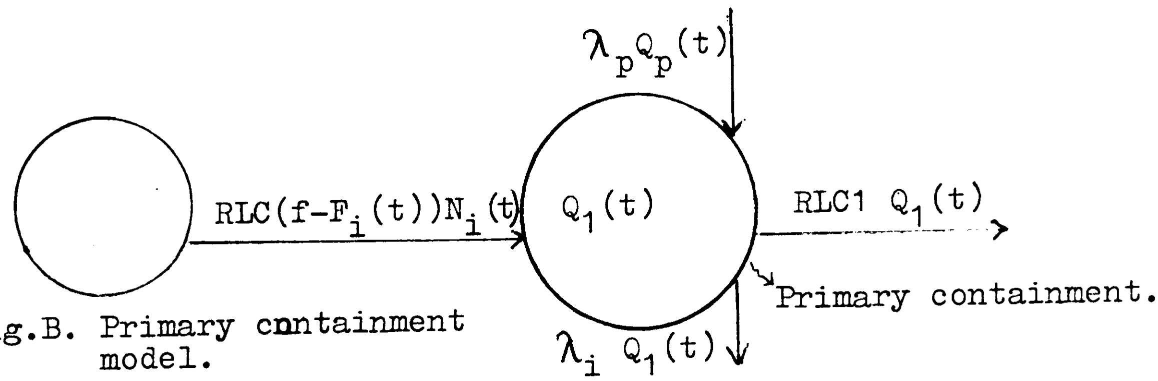

Fig.B. Primary containment model.

$Q_1(t)$ = The amount of isotope i held up in the primary containment at time t.

$Q_p(t)$ = The quantity of precursor p held up in the containment at time t.

and

RLC1 = The primary containment leakage constant per unit time.

The balance equation in this case is

$$\begin{aligned} \frac{d\,Q_1(t)}{dt} &= RLC\left[f - F_i(t)\right] Ni(t) + \lambda_p\, Q_p(t) \\ &\quad - \lambda_i\, Q_1(t) - RLC1\, Q_1(t), \end{aligned} \qquad (2.8)$$

The rate of change of $q_1(t) = \frac{Q_1(t)}{N_i(t)}$ can be obtained from Eq. (2.8) in a fashion similar to that used to derive Eq. (2.3) using Eq. (2.1); that is

$$\frac{dq_1(t)}{dt} + \lambda_p \left[1 - \frac{q_p(t)}{q_1(t)} \right] \frac{N_p(t)}{N_i(t)} q_1(t) + RLC1\ q_1(t) = RLC\ (f - F_i(t)) \qquad (2.9)$$

where $q_p(t) = \frac{Q_p(t)}{N_p(t)}$

If we assume that the precursor isotopes move through the containment in the same manner as the isotope i, then $q_1 = q_p$ and Eq. (2.9) reduces to

$$\frac{dq_1(t)}{dt} + RLC1\ q_1(t) = RLC\ (f - Fi(t)) \qquad (2.10)$$

Substituting the results obtained in Eqs. (2.5) through (2.7) in the right hand side of Eq. (2.10) and integrating we get

$$Q_1(t) = f\ N_i(t)\ \frac{\epsilon}{1-\epsilon} \left[e^{-\epsilon Q} - e^{-Q} \right], \qquad (2.11)$$

where

$$\epsilon = \frac{RLC}{RLC1}, \qquad Q = RLC1\ (t - t_o)$$

Equation (2.11) represents the exponential model solution, and from this equation one can get the step model solution

$$Q_1(t) = f\ N_i(t)\ e^{-Q}, \qquad (2.12)$$

in the limit of $\epsilon \to \infty$ or $RLC \to \infty$ which corresponds to instantaneous release from the primary system.

The quantity of isotope i released from a double a containment arrangement can be evaluated as above. In this case the three barriers model is shown in Fig.C, and the parameters are defined as follows:

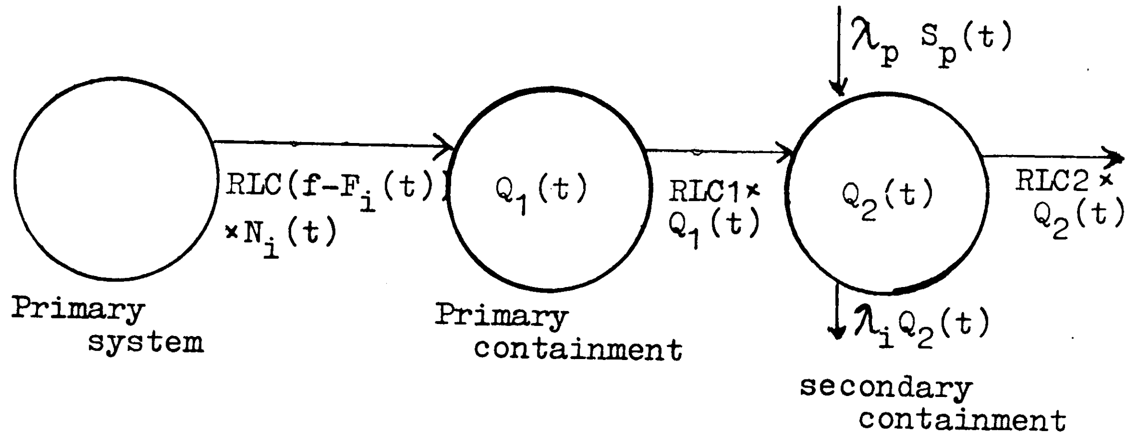

Fig. C. Double Containment Model.

$Q_2(t)$ = The quantity of isotope i held up in the secondary containment at time t.

$S_p(t)$ = The quantity of precursor p held up in the secondary containment at time t.

RLC2 = The leakage constant of the secondary containment per unit time.

$$q_2(t) = \frac{Q_2(t)}{N_i(t)}, \qquad s_p(t) = \frac{S_p(t)}{N_p(t)}$$

and the rest of the parameters are defined as before.

Assuming that $q_2(t) = s_p(t)$, the rate of change of the fraction $q_2(t)$ can be obtained by the same method used above for the first containment structure; thus,

$$\frac{dq_2(t)}{dt} + RLC2\, q_2(t) = RLC1\, q_1(t), \tag{2.13}$$

This equation can be integrated after using the proper value of RLC1 $q_1(t)$ from Eq. (2.11) or (2.12) to obtain the quantity of isotope i released from the second containment corresponding to the model of release of interest. It may be convenient to express the results in terms of a dimensionless quantity $L(\theta)$ defined as

$$L(\theta) = \frac{RLC2\; Q_2(t)}{f\; RLC1\; N_i(t)}, \tag{2.14}$$

where the quantity f RLC1 $N_i(t)$ is the instantaneous release of the isotope i from the primary containment. Thus,

a) exponential model:

$$L(\theta) = \frac{K}{K-1}\left[\frac{\epsilon}{K-\epsilon}\, e^{-KQ} - \frac{\epsilon}{1-\epsilon}\, e^{-Q} + \epsilon\left(\frac{1}{1-\epsilon} - \frac{1}{K-\epsilon}\right) e^{-\epsilon Q}\right] \tag{2.15}$$

where $K = RLC2/RLC1$

b) Step model:

$$L(\theta) = \frac{K}{K-1}\left[e^{-Q} - e^{-KQ}\right], \tag{2.16}$$

In the limit $K \to \infty$, Eqs. (2.15) and (2.16) reduce to Eqs. (2.11) and (2.12) respectively. Similarly Eq.(2.15) reduces to Eq. (2.16) in the limit $\epsilon \to \infty$.

3. DERIVATION OF THE ACTIVITY EQUATION:

To calculate the quantity of a given FP isotope formed during fission, it is necessary to obtain information about the following parameters:

a) irradiation time,

b) neutron flux of the reactor,

c) relative fission yield of each isotope along the decay chain and any branching ratio involved,

d) the decay constants of the isotopes,

e) neutron capture cross-sections of the nuclides,

Let us consider the simple chain shown below:

$$1 \xrightarrow{\lambda_1} 2 \xrightarrow{\lambda_2} 3 \xrightarrow{\lambda_3} \quad \ldots\ldots. i \longrightarrow \longrightarrow n$$

If the effect of irradiation on FP'S is negligible or with a clean reactor core, the rate of change of the first three isotopes is given by

$$\frac{dN_1}{dt} = y_1 F - \lambda_1 N_1 \; , \ldots\ldots\ldots\ldots (3.1)$$

$$\frac{dN_2}{dt} = y_2 F + \lambda_1 N_1 - \lambda_2 N_2 \ldots\ldots (3.2)$$

$$\frac{dN_3}{dt} = y_3 F + \lambda_2 N_2 - \lambda_3 N_3 \ldots\ldots. (3.3)$$

where N_1, N_2 & N_3 are the numbers of atoms of isotopes 1,2 and 3 respectively at time t.

y_1 , y_2 & y_3 are the yields of isotope 1, 2 and 3.

F is the fission rate

λ_1, λ_2 and λ_3 are the decay constants of isotopes 1,2 &3.

It is assumed that isotope 1 is produced instantaneously and that there is no burnup by neutron capture.

The activity of the isotopes 1, 2, & 3 can be obtained from the above equation by solving for the initial condition

$$N_1 = N_2 = N_3 = 0 \quad \text{at} \quad t = 0$$

Thus,

$$R_1 = N_1 \lambda_1 = y_1 F \left[1 - e^{-\lambda_1 t}\right] , \quad \ldots.. (3.4)$$

$$R_2 = \lambda_2 N_2 = (y_1 + y_2)\,F\,(1 - e^{-\lambda_2 t}) - \lambda_2\, y_1 F \left[\frac{e^{-\lambda_1 t}}{\lambda_2 - \lambda_1} + \frac{e^{-\lambda_2 t}}{\lambda_2 - \lambda_1}\right] \quad \ldots(3.5)$$

$$R_3 = \lambda_3 N_3 = (y_1 + y_2 + y_3)F\,[1 - e^{-\lambda_3 t}] - \lambda_3 (y_1 + y_2)\,F\left[\frac{e^{-\lambda_2 t}}{\lambda_3 - \lambda_2} + \frac{e^{-\lambda_3 t}}{\lambda_3 - \lambda_2}\right] - \lambda_2 \lambda_3\, y_1 F\left[\frac{e^{-\lambda_1 t}}{(\lambda_2 - \lambda_1)(\lambda_3 - \lambda_1)} + \frac{e^{-\lambda_2 t}}{(\lambda_1 - \lambda_2)(\lambda_3 - \lambda_2)} + \frac{e^{-\lambda_3 t}}{(\lambda_1 - \lambda_3)(\lambda_2 - \lambda_3)}\right] \quad \ldots(3.6)$$

where R_1, R_2 & R_3 are the activity of disintegration rate of isotops 1, 2 & 3.

For the Xe-135 isotope which has large neutron capture cross-section, we have used the following equation.

$$\frac{\partial X}{\partial t}(r,t) = \gamma_x\, \Sigma_f\, \Phi(r,t) + \lambda_I I(r,t) - \lambda_x X(r,t) - \sigma_a^x\, \Phi(r,t)\, X(r,t) \quad \ldots\ldots\ldots\ldots(3.7)$$

whose solution (9) is given by

$$X(t) = \frac{(\gamma_I + \gamma_X)}{(\lambda_x + \sigma_a^x \Phi_o)}\, \Sigma_f\, \Phi_o\, \left(1 - e^{-(\lambda_x + \sigma_a^x \Phi_o)t}\right) + \frac{\gamma_I\, \Sigma_f\, \Phi_o}{\lambda_x - \lambda_I + \sigma_a^x \Phi_o}\left[\exp\left(-(\lambda_x + \sigma_a^x \Phi_o)t\right) - e^{-\lambda_I t}\right] \quad \ldots\ldots\ldots(3.8)$$

4. RESULTS AND DISCUSSIONS:

Calculations performed are based on the following considerations:

(a) The reactor is assumed to be operating at steady state for one year at a power level of 1000 MW(th).

(b) The initial fuel element failure occured 15 minutes after the accident.

(c) The reactor is scrammed upon the onset of the accident condition so that the buildup of I-135 and Xe-135 will be

only due to the decay of the precursors and not by direct fission.

(d) 25% of the Iodine and Xenon escaped from the core as a gas.

(e) The reactor has a primary containment structure that leaks at a rate of 0.5% and 1.0% of the contained gas per day and a secondary containment structure that leaks at a rate of 500.0%, 1000.0% and 1500.0% per day.

(f) The primary system leaks at a rate of 600.0%, 1200.0% and 1800.0% per day.

Radiation release rate to the atmosphere from the primary containment structure of the PWR are then calculated hourly. These results are shown in Figures 1 to 6.

In Figure 1, we have compared the step and exponential model calculation of I-135 and Xe-135 release rate to the atmosphere from a primary containment leaking at the rate of 0.5% per day. Two important points may be observed from this Figure. Firstly, at one hour after the accident, the release rate of I-135 predicted by step model is about six times higher than that predicted by the exponential model. However as the isotope I-135 is decaying, the difference between the two model predictions become smaller with time. At ten hours after the accident, the step model predicted value for the I-135 release rate is about 9% higher than the corresponding value calculated by the exponential model. Secondly, the step model value is a decreasing function of time. Whereas the exponential model values increase with time upto about 5.5 hours and decrease afterwards. Similar behaviours are also observed for the Xe-135 release rates.

Figure 2 shows the release rates of I-135 and Xe-135 from a secondary containment leaking at the rate of 500.0% per day. It is observed that the exponential model values are much smaller than the step model values. In Figure 3, we have compared the release rates of I-135 and Xe-135 from the primary containment which is leaking at 0.5% per day and 1.0% per day. As expected, release rate is higher when the leakage rate of the primary containment is higher. Figure 4 shows the release rates from the primary containment for different values of the leakage rates from the primary system. The release rate from the primary containment is obviously highest when the leakage rate from the primary system is highest and this is what one would expect on physical ground. In Figure 5 we have compared the release rates of I-135 and Xe-135 from a secondary containment for different values of the release rates from the primary system. Again, we observe that the release rate from the secondary containment increases as the primary system leakage rate increases. Figure 6 shows the leakage rates of I-135 and Xe-135 from the secondary containment for different values of the leakage rates. The release rate increases as the leakage rate of the containment increases.

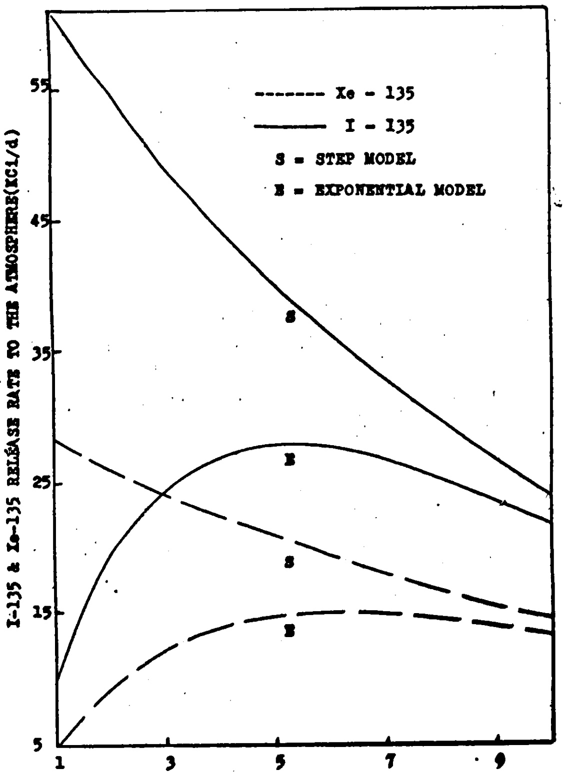

FIG.1 : I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE PRIMARY CONTAINMENT LEAKING AT THE RATE OF 0.5% PER DAY, HERE RLC = 600 % PER DAY

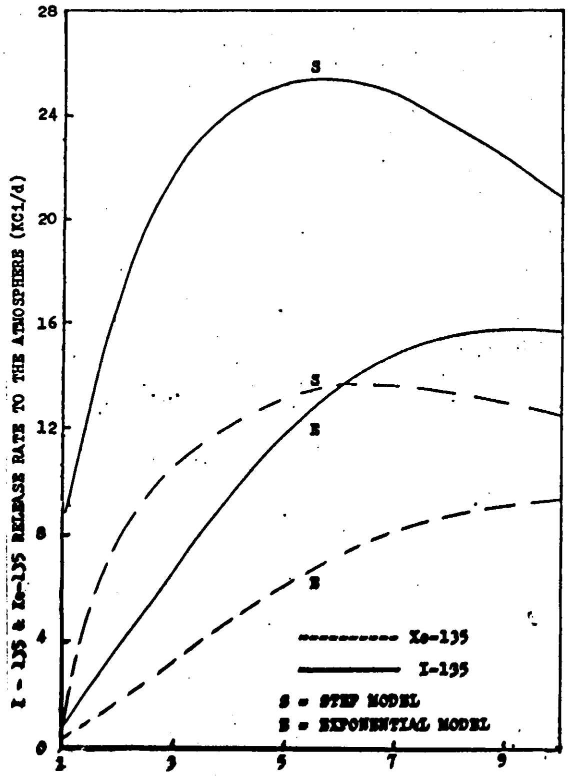

FIG.2 : I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE SECONDARY CONTAINMENT LEAKING AT THE RATE OF 500% PER DAY. HERE RLC1 = 0.5% PER DAY, RLC=600% PER DAY.

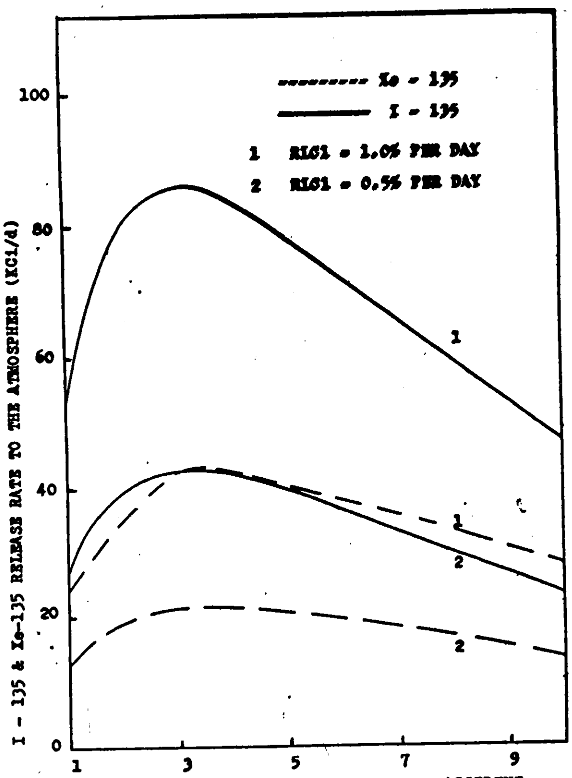

FIG.3 : I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE PRIMARY CONTAINMENT LEAKING AT THE RATE OF 0.5% PER DAY & 1.0% PER DAY. HERE RLC= 1800% PER DAY.

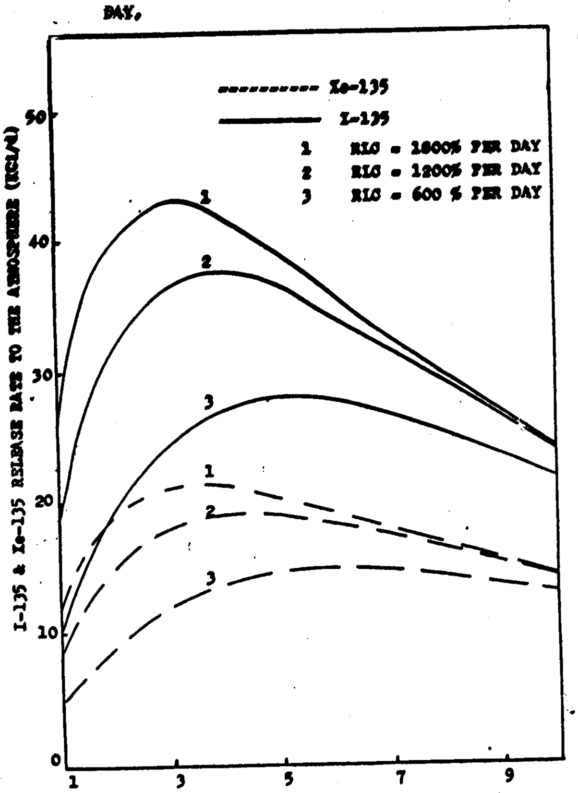

FIG.4: I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE PRIMARY CONTAINMENT LEAKING AT THE RATE OF 0.5% PER DAY USING EXPONENTIAL MODEL WITH VARIOUS VALUES OF RLC

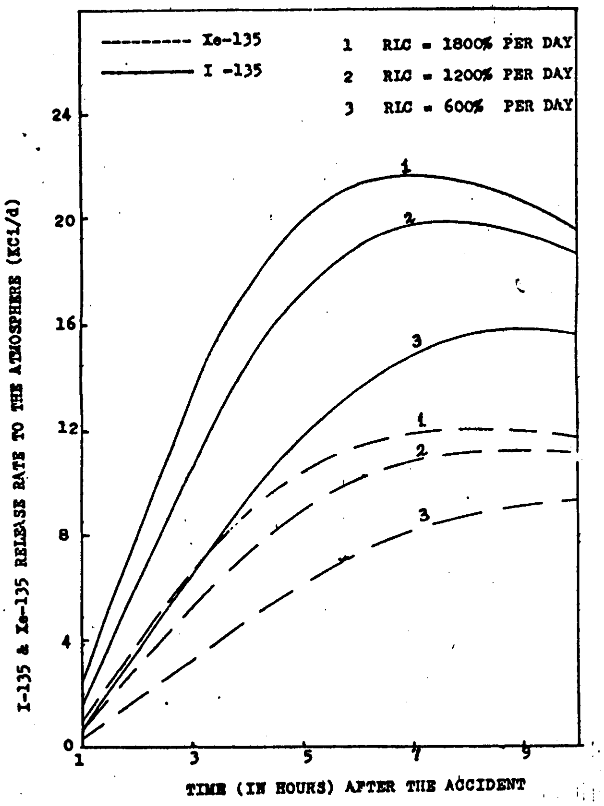

FIG.5 : I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE SECONDARY CONTAINMENT LEAKING AT THE RATE OF 500 % PER DAY USING VARIOUS VALUES OF RLC

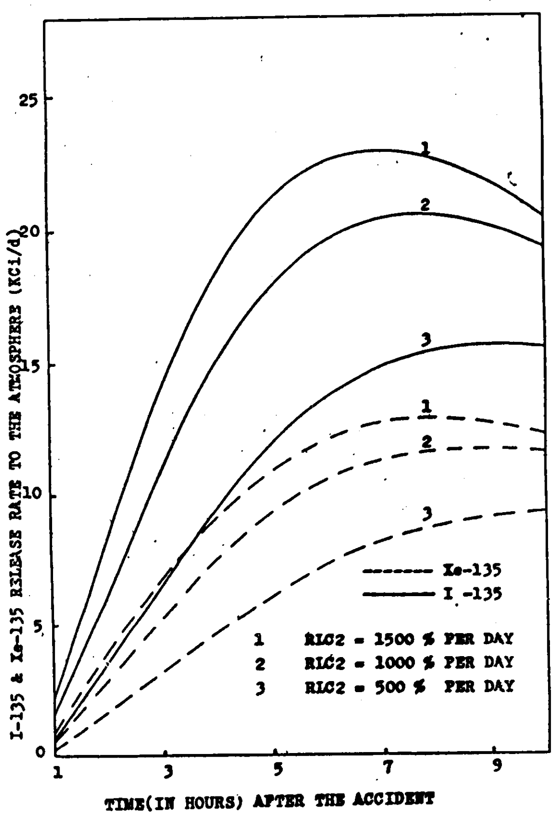

FIG.6: I-135 & Xe-135 RELEASE RATE TO THE ATMOSPHERE FROM THE SECONDARY CONTAINMENT LEAKING AT DIFFERENT RATES HERE RLC = 600 % PER DAY, RLC1 = 0.5 % PER DAY.

5. CONCLUSIONS:

It is found from the results that:

1. The release rate of the radioactivity, as expected, increases as the leakage rate of the containment structure increases.

2. The use of a secondary containment, which may be leaking at a high rate, greatly reduces the release rate of the radiations to the atmosphere. This is very much desired from the safety point of view of the nuclear power plants.

3. To calculate the fission product activity release rate to the environment from the different barriers of a nuclear power plant one should prefer the exponential release model to the step model.

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SAFETY OF NUCLEAR-REACTOR STRUCTURES
A: HEAT TRANSFER (FIRE) MATHEMATICAL MODEL

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ABSTRACT:

Safety of nuclear reactor structures under excessive load and/or heat (fire) stresses at near melt-down condition requires a careful study. Two mathematical models have been thoroughly studied to examine the endurance limit of a circular column structure member made out of concrete reinforced with steel bars. The model presented here deals with the heat (fire) transfer to the column at elevated temperature condition. The solution of the problem is based on a finite difference method for calculating the temperature history of cylindrical composite member [1, 2, 3, 4].

INTRODUCTION:

The energy produced by fissioning process in a nuclear reactor appears in several forms, each of which eventually degrades to heat. To provide for removal of this heat, the core, or active portion of the nuclear reactor, usually consists of uranium-bearing fuel elements with passages around these elements for flow of coolant. The rate of coolant flow and the temperature of the coolant must be such as to permit removal of all the heat generated in the elements without exceeding allowable material properties.

The mechanical design of nuclear reactors, however is influenced by factors not encountered with other apparatus e.g. the need to control criticality, the effects of irradiation and the high power density produced in the core. Abnormal operations of a nuclear reactor vary from delay in shutdown operation in case of malfunction to a case of near melt-down.

During normal operation, components of the core must be rigid enough so that deflections due to mechanical and/or thermal stresses do not introduce, unpredicted criticality variations. The design and control of nuclear reactor structure

and control system must stand the worst of conditions. If a major accident takes place at a nuclear reactor safety would be of a major concern to all. The latest accident at the Chernobyl (U.S.S.R) nuclear reactor flared a wave of scientific and public concern as to the safety of nuclear reactor structure especially under abnormal conditions.

NATURE OF THE PROBLEM:

Nuclear reactor structures under abnormal operations of near melt-down will be exposed to a tremendous amount of heat flux in addition to the stress field applied under normal operation. Temperature encountered in such case is assumed to be beyond 1000 ^{o}C [1] . A mathematical model describing the behaviour of circular column structures of concrete reinforced with steel bars under load and heat has been thoroughly examined in this paper. Effects due to nuclear radiation and mechanical vibrations will be explored in a later future model. The main goal of this model is: (1) to study the structure member characteristics (temperature, deformation and strength) under excessive heat (fire) conditions, (2) to study the possibility of increasing the indurance time by changing the column composite structure.

The following discussion deals with heat (fire) mathematical model analysis.

APPROACH AND METHOD OF SOLUTION:

The cross-sectional area of the column is sub-divided into a number of concentric layers (M). As illustrated in Figure 1a,1b the outer layer of concrete, which is exposed to fire, has a thickness of $\frac{1}{2}(\Delta\rho)$. The thickness of the last concrete layer at the center is also $\frac{1}{2}(\Delta\rho)$. The thickness of all other layers in the cross-section is $\Delta\rho$.

It is assumed that the entire surface of the column is exposed to the heat of a fire whose temperature course follows that of standard fire described in ASTM-E119 [5] . This temperature course can be described by the following expression:

$$T_f^j = 20 + 750\left[1 - \exp(-3.79553\sqrt{t})\right] + 170.41\sqrt{t} \quad (1)$$

where t is the time in hours and T_f^j is the fire temperature in ^{o}C at time $t = j\,\Delta t$.

A. EQUATIONS OF FIRE/CONCRETE BOUNDARY:

The temperature rise in each layer can be derived by making a heat balance for it, i.e. by applying the non-linear unsteady state partial differential equation and its numerical solution, for each layer. Also, the heat transferred by radiation to the surface boundary layer must be taken into account. This heat will be transmitted from the fire to a surface layer by radiation through Equation (1). For the fire/concrete boundary, the heat transmitted by radiation to the boundary surface layer during the period $j\Delta t \leqslant (j+1)\,\Delta t$ for a unit height of the columns is

as follows:

$$q_R = (A_{rs})\sigma \epsilon_f \epsilon_c \left[(T_f^j + 273)^4 - (T_{m-1}^j + 273)^4\right], \quad (2)$$

Where

$$A_{rs} = 2\pi(M-1)\Delta\rho \text{ and } m = 2$$

From Figure (1), heat is transferred from point 1 to point 2 in the radial direction of the cross-section by conduction. This heat is dependent on the radial direction (r), temperature (T) and thermal conductivity (K) as follows:

$$\left\{\frac{1}{r}\frac{\partial}{\partial r}\left(Kr\frac{\partial T}{\partial r}\right)(A_r)_{f/c}\right\} = \left(\rho c \frac{\partial T}{\partial t}\right)(A_r)_{f/c} \quad (3)$$

From Figure (1) and using the finite difference method, the solution for equation (3) is:

$$T_{m-1}^{j+1} = T_{m-1}^{j} + \frac{\Delta t}{(\rho_c c_c)^j_{m-1}\left(M-\frac{5}{4}\right)\frac{(\Delta\rho)^2}{2} + \frac{\rho_w C_w}{2\pi} V_{m-1}^j}$$

$$\left\{(M-1)\Delta\rho\sigma\epsilon_f\,\epsilon_c\left[(T_f^j + 273)^4 - (T_{m-1}^j + 273)^4\right] - \left(\frac{(K^j)_m + (K)^j_{m-1}}{2}\right)\left(M-\frac{3}{2}\right)(T_{m-1}^j - T_m^j)\right\} \quad (4)$$

B. EQUATIONS AT INSIDE CONCRETE REGION:

The heat transfer by conduction through a layer at point P_m can be found by applying Equation (3) and its numerical solution to the concrete layers except for the layer at the boundary and the centre layer.

The finite difference method solution for equation (3) in this region is (Figure 2a, 2b).

$$T_1^{j+1} = T_m^j + \frac{\Delta t}{(\rho_c\, c_c)^j (M-m)(\Delta\rho)^2\ \frac{\rho_w C_w}{2\pi}(2\pi)(M-m)\,\phi_m^j(\Delta\rho)^2}$$

$$\left\{\left(M-m+\tfrac{1}{2}\right)\left(\frac{K_{m-1}^j + K_m^j}{2}\right)(T_{m-1}^j - T_m^j) - \left(M-m-\tfrac{1}{2}\right)\left(\frac{K_{m+1}^j + K_m^j}{2}\right)(T_m^j - R_{m+1}^j)\right\} \quad (5)$$

But

$$V_m^j = \left[(A_r)_m \times 1.0\right](\phi_m^j)$$

$$= \left[2\pi r_m(\Delta\rho)(1.0)\quad(\phi_m^j)\right]$$

$$= \left[2\pi (M-m)(\Delta\rho)^2 \; (1.0) \quad (\phi_m^j) \right]$$

$$V_m^j = \left[2\pi (M-m) \, \phi_m^j \, (\Delta\rho)^2 \right] \tag{6}$$

By substituting Equation (6) into Equation (5) and using the moisture volume V_m^j we get:

$$T_m^{j+1} = T_m^j + \frac{\Delta t}{(\rho_c C_c)^j (M-m)(\Delta\rho)^2 + \frac{\rho_w C_w}{2\pi} V_m^j} \left\{ (M-m+\tfrac{1}{2}) \left(\frac{K_{m-1}^j + K_m^j}{2} \right) (T_{m-1}^j - T_m^j) - (M-m-\tfrac{1}{2}) \left(\frac{K_{m+1}^j + K_m^j}{2} \right) (T_m^j - T_{m+1}^j) \right\} \tag{7}$$

C. EQUATIONS FOR THE CENTRE CONCRETE LAYER:

Similarly as before, by applying Equation (3) and its numerical solution to the centre layer we get the temperature T_M^{j+1} at the time $(j+1)\Delta t$ as (Figure 3a, 3b).

$$T_M^{j+1} = T_M^j + \frac{\Delta t}{\left[(\rho_c C_c)_M^j \frac{(\Delta\rho)^2}{4} + \frac{\rho_w C_w}{\pi} (\pi) \frac{(\Delta\rho)^2}{4} \phi_M^j \right]} \left\{ \left[\frac{(K^j)_M + (K^j)_{M-1}}{2} \right] \left[(T^j)_{M-1} - (T^j)_M \right] \right\} \tag{8}$$

But: $$V_M^j = \left[(A_r)_M \times 1.0 \right] (\phi_M^j)$$

$$V_M^j = \left[\pi \frac{(\Delta\rho)^2}{4} \times 1.0 \right] (\phi_M^j)$$

By substituting the value of V_M^j into Equation (8), the final equation in terms of moisture volume is:

$$T_M^{j+1} = T_M^j + \frac{\Delta t}{(\rho_c C_c)_M^j \left(\frac{(\Delta\rho)^2}{4} \right) + \frac{\rho_w C_w}{\pi} V_M^j} \left\{ \left[\frac{(K^j)_M + (K^j)_{M-1}}{2} \; (T^j)_{M-1} - (T^j)_M \right] \right\} \tag{9}$$

D. STABILITY CRITERION:

In order to ensure that any error existing in the solution at some time level will not be amplified in the subsequent calculations, a stability criterion has to be satisfied; for a selected value of $\Delta\rho$, this limits the maximum time step Δt. Following the method described in reference [6], it can be

derived that for the fire-exposed column the criterion of stability is most restrictive along the boundary between fire and concrete it is given by the condition:

$$\Delta t \leqslant \frac{(\rho_c c_c)_{min} (\Delta \xi)^2}{2(K_{max} + h_{max} \Delta \xi)} \tag{10}$$

where $(\rho_c c_c)_{min}$ is the minimum value of the heat capacity of the steel, K_{max} the maximum value of its thermal conductivity and h_{max} the maximum value of the coefficient of heat transfer to be expected during the exposure to fire.

E. EFFECT OF MOISTURE:

The effect of moisture in the concrete is taken into account by assuming that in each layer the moisture starts to evaporate when the temperature reaches 100°C. In the period of evaporation, all the heat supplied to a layer is used for evaporation of the moisture until the layer is dry. To calculate the change in the moisture content, first the initial moisture has to be calculated at the boundary, inside concrete region and the center layer. The equations are given as:

$$V_{m-1} = \left[(A_r)_{f/c} \; (1.0) \right] \; (\phi) \tag{11}$$

$$V_m = \left[(A_r)_m \; (1.0) \right] \; (\phi) \tag{12}$$

$$V_M = \left[(A_r)_M \; (1.0) \right] \; (\phi) \tag{13}$$

Assuming ΔV_{m-1} as the change in volume of the moisture content in fire/concrete boundary layer, the moisture concentration can be calculated as:

$$\phi^{j+1}_{m-1} = \phi^{j}_{m-1} + \frac{\Delta t}{\rho_w \lambda_w (M - \frac{5}{4}) \frac{(\Delta \xi)^2}{2}} \left\{ (M-1) \sigma \epsilon_f \epsilon_c \Delta \xi \left[(T^j_f + 273)^4 - (T^j_{m-1} + 273)^4 \right] - \left[\left(\frac{(K^j)_m + (K)^j_{m-1}}{2} \right) (M - \frac{3}{2}) (T^j_{m-1} - T^j_m) \right] \right\} \tag{14}$$

Where: V^{j+1}_{m-1} **can be obtained from:**

$$V^{j+1}_{m-1} = V^{j}_{m-1} + \frac{2\pi \Delta t}{\rho_w \lambda_w} \left\{ (M-1) \Delta \xi \sigma \epsilon_f \epsilon_c \left[(T^j_f + 273)^4 - (T^j_{m-1} + 273)^4 \right] - \left[\left(\frac{(K^j)_m + (K^j)_{m-1}}{2} \right) (M - \frac{3}{2}) (T^j_{m-1} - T^j_m) \right] \right\} \tag{15}$$

The moisture content for the layer at inside concrete region at the time t = (j+1)Δt is given by:

$$\Phi_m^{j+1} = \Phi_m^j + \frac{\Delta t}{(\rho_w \lambda_w)\left[(M-m)(\Delta\rho)^2\right]}\left\{\left(\frac{(K^j)_{m-1}+(K^j)_m}{2}\right)(M-m+\tfrac{1}{2})(T^j_{m-1} - T^j_m) - \left(\frac{(K^j)_{m+1} + (K^j)_m}{2}\right)(M-m-\tfrac{1}{2})(T^j_m - T^j_{m+1})\right\} \quad (16)$$

Where ΔV_m can be found from:

$$V_m^{j+1} = V_m^j + \frac{2\pi(\Delta t)}{\rho_w \lambda_w}\left\{\left(\frac{(K^j)_{m-1}+(K^j)_m}{2}\right)(M-m+\tfrac{1}{2})(T^j_{m-1}-T^j_m) - \left(\frac{(K^j)_{m+1} + (K^j)_m}{2}\right)(M-m-\tfrac{1}{2})(T^j_m - T^j_{m+1})\right\} \quad (17)$$

The volume of moisture content (ΔV_M), evaporated in the time Δt from the centre layer is as follows:

The moisture content for the center layer at the time t = (j+1)Δt is:

$$\Phi_M^{j+1} = \Phi_M^j + \frac{\Delta t}{\rho_w \lambda_w\left(\frac{(\Delta\rho)^2}{4}\right)}\left[\frac{(K^j)_M+(K^j)_{M-1}}{2}\right]\left[(T^j)_{M-1}-(T^j)_M\right] \quad (18)$$

Where ΔV_M^{j+1} can be determined from:

$$V_M^{j+1} = V_M^j + \frac{\pi(\Delta t)}{\rho_w \lambda_w}\left[\frac{(K^j)_M + (K^j)_{M-1}}{2}\right]\left[(T^j)_{M-1}-(T^j)_M\right] \quad (19)$$

The previously developed equations represent the heat transfer mathematical model. This model is the crux of the structure mathematical model which predicts the endurance strength of the composite member at elevated temperature. The structure mathematical model and results of model application will be published separately.

NOMENCLATURE:

A_r Cross section area of the boundary layer

A_{rs} Surface area of the boundary layer located on the longitudinal surface of the column.

$(A_r)_{f/c}$ the area of fire/concrete boundary layer.

$(A_r)_m$ mean perimeter X$\Delta\rho$, the cross-section area of the mth layer.

$(A_r)_M$	the area of the centre concrete layer and M is the total number of layers.
C	specific heat, J/Kg ^oC.
h	coefficient of heat transfer at fire exposed surface, $W/m^2\ ^oC$.
m, M	layer number and number of layers.
M_1	number of points P in radial direction
N_1	number of elements in tangential direction.
P	Point
$(q_R)_{f \rightarrow (m-1)}$	the heat transfer from the fire to the fire/concrete boundary layer by radiation, $\frac{J}{m.hr.}$ Equation (2)
$(q_c)_{(m-1) \rightarrow m}$	the heat transfer by conduction from layer (m-1) to layer m, J/(m.hr), Equation (3), where m = 2
$(q_v)_{m-1}$	the heat used for evaporization of the moisture content of layer (m-1), $\frac{J}{m.hr}$. This heat of evaporization will continue until the layer becomes dry, then the heat used to raise the layer temperature is called the sensible heat.
$(q_v)_{m-1}$	(water density)(heat of vaporization)(Volume of the layer)(Change of moisture concentration with respect to time).
R_1	inner radius of the boundary layer
R_O	Outer radius of the column-section temperature
T	Temperature
T^{j+1}_{m-1}	the temperature at time t = (j+1) Δt, ^oC
T^{j}_{m-1}	the temperature at time t = j Δt, ^oC
t	time
V	Volume of water in an element, m^3
V_{m-1}	Volume of moisture content with the first layer where m = 2
V_{mc}	Volume of moisture content for the concrete element.
V_M	Volume of moisture for the centre concrete layer.
ΔV_M	Change in the volume of the moisture content.

Greek Letters:

α	Coefficient of thermal expansion
Δ	Increment or difference
ϵ	Emissivity
λ	Heat of vaporization, J/Kg

ρ	density kg/m^3
σ	Stefan-Boltzman constant, W/m^2 °K^4
Φ	Concentration of moisture (fraction of volume)
$(\rho_c C_c^j)_{m-1}$	thermal capacity of concrete, J/m^3 °C
$\rho_w C_w$	thermal capacity of water, J/m^3 °C
Φ_{m-1}^j	concentration of moisture (volume fraction)
Δt	time in hours
$\Delta\xi$	the width of the layer, m
$\frac{\Delta\xi}{2}$	the thickness of fire/concrete boundary layer and the layer at the centre of the column.
	the thickness of the layers except the fire/concrete boundary and the centre layers.

SUBSCRIPTS:

o	at room temperature
c	of concrete
f	of the fire
m, M	at the points m, M in radial direction
max	maximum
min	minimum
n, N	at the points n, N in tangential direction
s	of steel
T	Pertaining to temperature
W	of water

SUPERSCRIPTS:

j at $t = j\,\Delta t$

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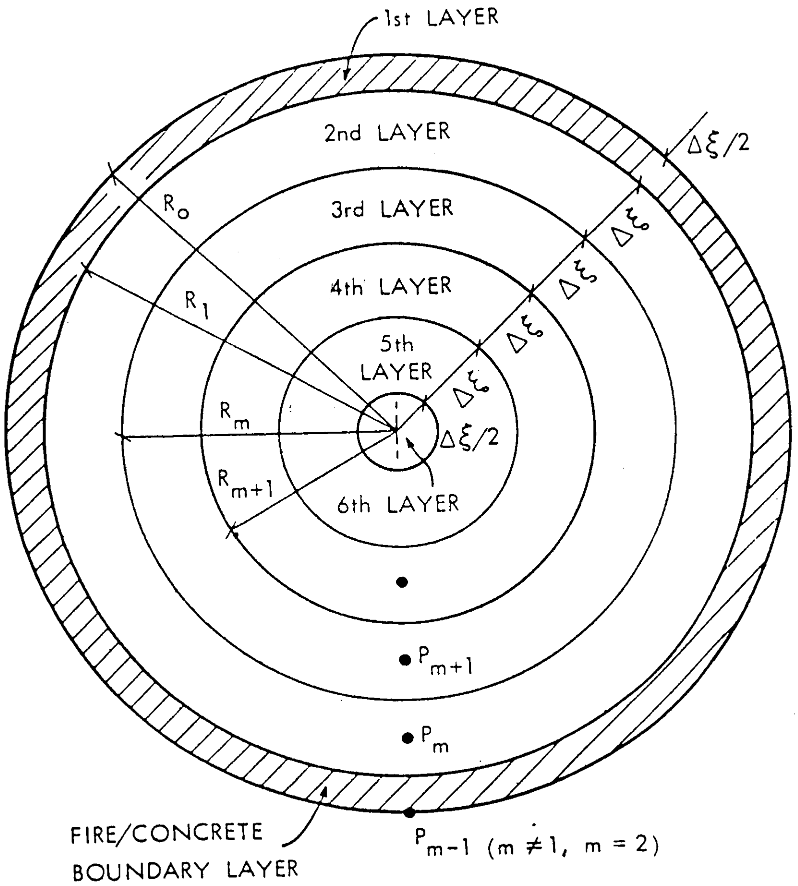

FIGURE 1a

ARRANGEMENT OF ELEMENTARY LAYERS IN SECTION OF REINFORCED CONCRETE CYLINDRICAL COLUMN

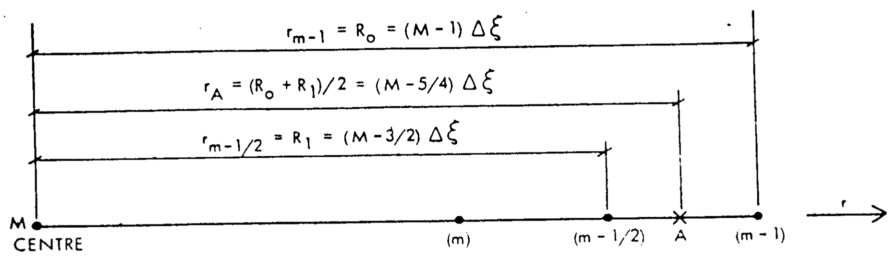

FIGURE 1b

ENLARGED SCALE FOR POINTS $P_{(m)}$, $P_{(m-1/2)}$ AND $P_{(m-1)}$

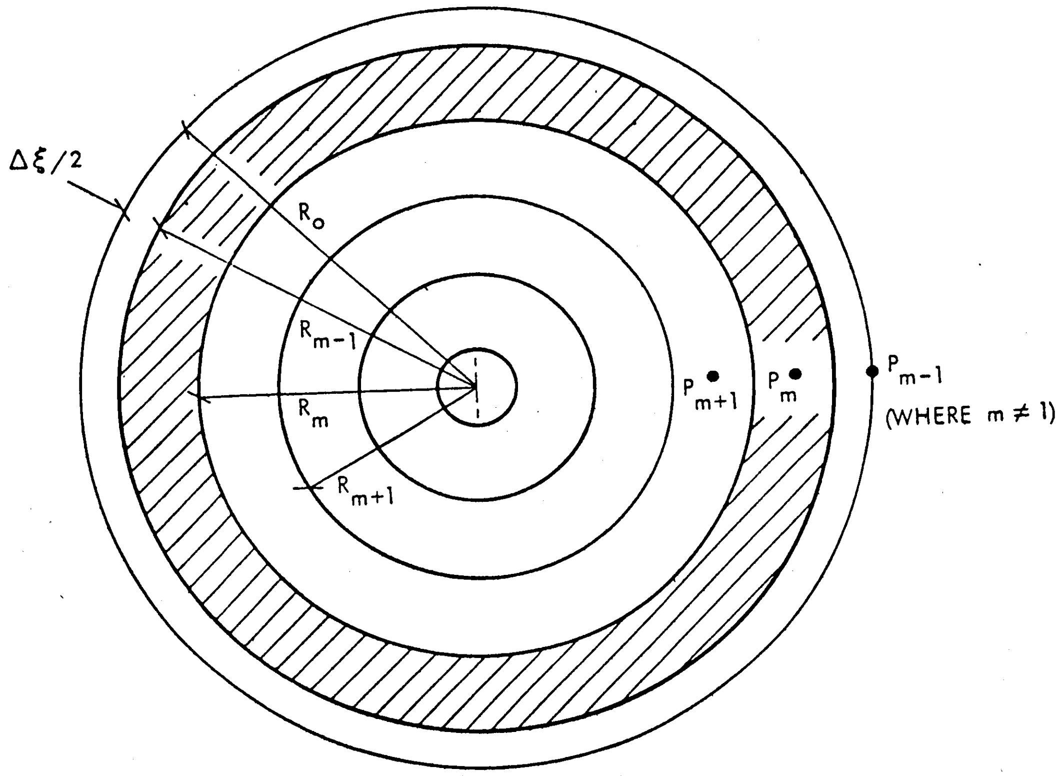

FIGURE 2a

LAYER AT INSIDE CONCRETE REGION

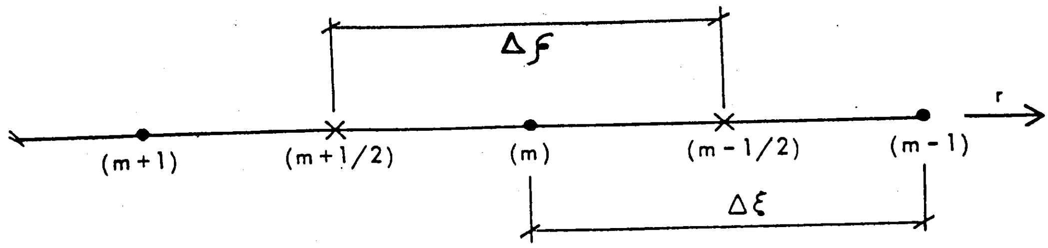

FIGURE 2b

ENLARGED SCALE FOR POINTS $P_{(m+1)}$, $P_{(m)}$ AND $P_{(m-1)}$

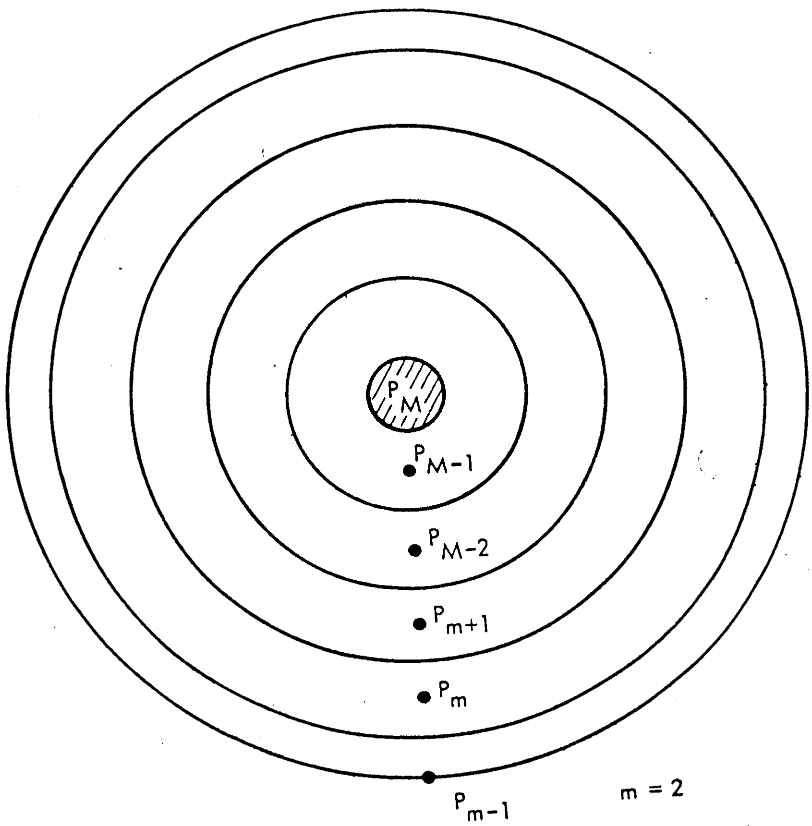

FIGURE 3a

THE CONCRETE LAYER AT THE CENTRE OF THE CROSS-SECTION

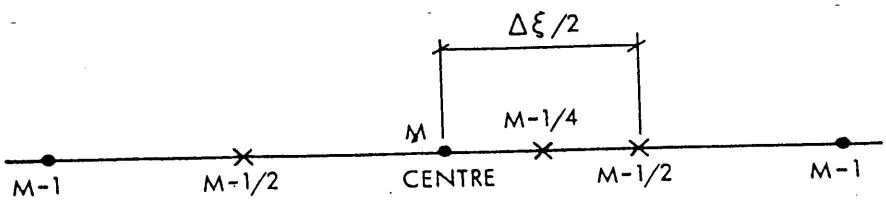

FIGURE 3b

ENLARGED SCALE FOR POINTS P_M AND P_{M-1}

SAFETY OF NUCLEAR REACTOR STRUCTURES

B: MECHANICAL STRENGTH MATHEMATICAL MODEL AT ELEVATED TEMPERATURE

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ABSTRACT

Safety of nuclear-reactor structures under excessive load and/or heat (fire) stresses at near melt-down condition requires a careful study. Two mathematical models have been studied to examine the endurance limit of circular column structure member made out of concrete reinforced with steel bars. The model presented here deals with the mechanical strength of the column at elevated temperatures. Results of model application will also be presented at the end of this paper.

NOMENCLATURE

$(A_c)_L$ = the area of concrete layer
$(A_s)_L$ = the area of steel layer
f_c = compressive strength of concrete at temperature T (MPa)
f'_c = cylinder strength of concrete at temperature T (MPa)
f'_{co} = cylinder strength of concrete at room temperature (MPa)
f_y = strength of steel at temperature T (MPa)
f_{yo} = yield strength of steel at room temperature (MPa)
$(f_{cR})_L$ = the compressive strength of the concrete layer right of x-axis
$(f_{cL})_L$ = the compressive strength of the concrete layer left of x-axis
KL = effective length of column (m)
$(M_c)_T$ = the total moment due to the total load carried by concrete
$(P_s)_T$ = the total load that the steel can carry
x = coordinate
y = lateral deflection of column at mid-height (m)
z = coordinate
z_c = horizontal distance of the center of the element to the vertical plane through the x-axis of the column section.

ρ = radius of curvature

$(\rho_c)_T$ = the total load which can be carried by concrete

$(\epsilon_T)_c$ = free strain due to thermal expansion of the concrete

ϵ = axial strain of the column

$(\epsilon_T)_S$ = free strain due to thermal expansion of steel.

ΔT = temperature change of the element

= T - 20

α_S = coefficient of thermal expansion of steel

Subscripts

o = at room temperature
c = of concrete
f = of the fire
m,M = at the points m, M in radial direction
max = maximum
min = minimum
n,N = at the points n, N in tangential direction
L = left of x-axis
R = right of x-axis
P = pertaining to proportional stress-strain relation
S = of steel
T = pertaining to temperature.

A - INTRODUCTION:

To calculate the deformation and stresses in the composite column, the cross sectional area of the column is subdivided into a number of annular elements. In Figure (1) the arrangement of the elements is shown in a quarter section of the column. The arrangement of elements in the three other quarter sections is identical to this. In tangential direction each quarter layer is divided into N elements. The temperature representative of an element is assumed to be that at the centre of the element. This can be obtained by taking the average of the temperature at the tangential boundaries of each element, previously calculated with the aid of the heat transfer equations.

Thus for an element $P_{m,n}$ in the cross-section except for the reinforcement, the representative temperature is:

$$(T^j_{m,n})_{annular} = \left(\frac{T^j_{m-1} + T^j_m}{2}\right)_{layer}, \text{ (where } m = 2)_{layer} \tag{1}$$

and if the location of the reinforcement at the centre of an element $P_{m,n}$, the representative temperature is:

$$(T^j_{m,n})_{annular} = (T^j_{reinfor.})_{layer} \tag{2}$$

It is assumed that the stresses and deformations at the centre of an element are representative of the whole element.

B. ASSUMPTIONS:

In the calculation of column strength the following assumptions were made:

1) The influence of the presence of reinforcing steel on the temperature may be neglected. Thus the column, from a thermal point of view, may be treated as consisting entirely of concrete. The temperature of the steel is assumed to be equal to the temperature in the column section at the location of the centre of the steel.

2) Concrete has no tensile strength

3) Plane sections remain plane.

4) Initial strains in the column before the exposure to fire consists of free shrinkage of the concrete and creep. Because the shrinkage of the column during test normally is compensated by filling the spaces at both ends of the column between the concrete and steel with a plaster, the shrinkage is assumed to be negligible.

The tests of the columns are usually started after a preloading period of about one hour. The shortening of the column due to creep during this period is assumed to be negligible. The initial creep can be eliminated by selecting the length of the shortened column as the reference length from which the axial strain of the column during the test is measured.

Based on these assumptions, the change of column strength during exposure to fire was calculated. In the calculations the network of annular elements shown in Figure (1) was used. Because the strains and stresses of the elements are not symmetrical with respect to the x-axis, the calculations were performed for both the network shown and an identical network at the left of x-axis. The load that the column can carry and the moments in the section were obtained by adding the loads carried by each element and the moments contributed by them.

C - CALCULATION OF STRENGTH DURING FIRE:

The most important mechanical properties that determine the strength of cylindrical reinforced concrete columns are compressive strength (f'_c), modulus of elasticity (E_c) and ultimate strain (ϵ_u) of the concrete, and the yield strength (f_y) and modulus of elasticity (E_s) of the steel. A survey of the literature [1] shows that the variation of these properties with temperature is influenced by a large number of factors. The compressive strength of concrete at elevated temperatures is affected by the rate and duration of heating, the size and shape of the test specimen, and the loading during heating.

During exposure to fire the strength of the column decreases with the duration of exposure. The strength of the column can be calculated by a method based on load-deflection analysis which in turn is based on a stress-strain analysis of cross-sections [2]. In this method, the columns, which are fixed at the ends during the tests, are idealized as pin-ended columns of reduced length KL (Figure 2). The load on the test columns is intended to be concentric. To represent imperfections in the columns, an initial deflection y_o = 2.5 mm (0.1 in.) is assumed.

D - CALCULATION OF STRAINS, STRESSES, LOADS AND MOMENTS OF STEEL:

The strain in an element of the steel due to the thermal expansion is given by:

$$(\epsilon_T)_S = \alpha_S(\Delta T) \qquad (3)$$

For any given curvature χ, and thus for any given deflection at mid-height y, the axial strain ϵ is varied until the internal moment (due to temperature change) at the mid-section is in equilibrium with the applied moment given by the product:

$$\text{Load x (deflection + eccentricity)} \tag{4}$$

Where

ϵ = axial strain, is varied until equilibrium

and $y = \chi (KL)^2/12$

If Z_s is the horizontal distance of the steel element to the vertical plane through the x-axis of the column section as illustrated in Figure(1) and ρ is the radius of curvature, then the strain due to bending of the column is:

$$\epsilon_b = \frac{Z_s}{\rho} \tag{5}$$

Therefore, the total strain in an element of the steel can be given as the sum of equations (3),(4) and (5). For the steel at the right of the x-axis the strain $(\epsilon_s)_R$ is given by:

$$(\epsilon_s)_R = -(\epsilon_T)_s + \frac{Z_s}{\rho} + \epsilon \tag{6}$$

For the steel elements at the left of the x-axis the strain $(\epsilon_s)_L$ is given by:

$$(\epsilon_s)_L = -(\epsilon_T)_S + \epsilon - \frac{Z_s}{\rho} \tag{7}$$

The stresses in the elements of the network are calculated using stress-strain relations given in reference [3] and [4]. These relations can be derived from data provided by Ingberg and Sale [5], and Witteveen, Twilt and Bylaard [6]. These relations include the effect of creep at elevated temperatures and were obtained at heating rates approximately those that occur in a fire in actual practice. The relations have been generalized for other structural steels by assuming that, for a given temperature, the curves are the same for all steels, but the stress below with the stress-strain relation is linear, is proportional to the yield strength of the steel. The equations that describe the relation between the stress in the steel (f_y) the strain (ϵ_s) and the temperature of the steel (T) are as follows [3, 4]:

$$\text{For } \epsilon_s < \epsilon_p, \quad f_y = \frac{f(T,0.001)}{0.001}\epsilon_s \tag{8}$$

where $\epsilon_p = 4 \times 10^{-6} f_{yo}$

and

$$f(T,0.001) = (50-0.04T)\text{x}\left[1-\exp(-30+0.03T)\sqrt{0.001}\right] \text{ x } 6.9$$

for

$$\epsilon_s > \epsilon_p$$

$$f_y = \frac{f(T,0.001)}{0.001}\epsilon_p + f[T,(\epsilon_s - \epsilon_p + 0.001)] - f(T,0.001) \tag{9}$$

With the aid of Equations (3) - (9) the stresses at mid-height in the steel can be calculated for any value of the axial strain (ϵ), curvature ($1/\rho$) and temperature (T). From these stresses the load that the steel carries and the contribution of the steel to the moments can be derived.

The total load that the steel carries can be calculated by the summation of the product of stress by the area for each element located in right and left side of the x-axis of the column cross section as the following:

The total load in steel is:

$$(P_s)_T = 2\left[\sum_{e=1}^{N} (f_{y_{SR}})_e (A_s)_e + \sum_{e=1}^{N} (f_{y_{SL}})_e (A_s)_e\right] \tag{10}$$

The total moment due to the contribution of the total load carried by steel can be calculated by the summation of the product of stress by area by z coordinate of the steel for each element located in right and left side of the x-axis of the column cross section as:

The total moment in steel is:

$$(M_s)_T = 2\left[\sum_{e=1}^{N} (f_{y_{SR}})_e (A_s)_e (Z_s)_e + \sum_{e=1}^{N} (f_{y_{SL}})_e (A_s)_e (-Z_s)_e\right] \tag{11}$$

E - CALCULATIONS OF STRAINS, STRESSES, LOADS AND MOMENTS IN CONCRETE:

In the same way as applied for steel, the strain in concrete causing stresses for elements at the right of the x-axis Figure 1. can be given by:

$$(\epsilon_c)_R = -(\epsilon_T)_c + \epsilon + \frac{z_c}{\rho} \tag{12}$$

and for elements at the left of the x-axis by:

$$(\epsilon_c)_L = -(\epsilon_T)_c + \epsilon - \frac{z_c}{\rho} \tag{13}$$

The stresses in the elements are calculated using the stress-strain relations described in Reference [3] and [4]. These relations were based on the work of Ritter [7] and Hognestad [8]. The relations have been slightly modified to take into account the creep of concrete at elevated temperatures. The modifications are based on results of work by Schneider and Haksever [9] and consist of a movement of the maxima in the stress-strain curves to higher strains with higher temperatures. The equations that describe these curves are as follows [3, 4]:

$$\text{for } \epsilon_c < \epsilon_{max}, \quad f_c = f'_c\left[1 - \left\{\frac{\epsilon_{max} - \epsilon_c}{\epsilon_{max}}\right\}^2\right] \tag{14}$$

$$\text{for } \epsilon_c > \epsilon_{max}, \quad f_c = f'_c \left[1 - \left\{ \frac{\epsilon_c - \epsilon_{max}}{3\epsilon_{max}} \right\}^2 \right] \qquad (15)$$

where

$$f'_c = f'_{co} \quad \text{if } T < 450^\circ C$$

$$f'_c = f'_{co} \left[2.011 - 2.353 \ \frac{T-20}{1000} \right] \text{ if } T > 450^\circ C$$

$$\epsilon_{max} = 0.0025 + (6.0T + 0.04T^2) \times 10^{-6}$$

With the aid of Equations (12) - (15) the stresses in each of the concrete elements at midsection can be calculated for any value of the axial strain (ϵ) and curvature ($1/\rho$). From these stresses the load that the concrete carries and the contribution of the concrete to the moments can be derived.

In the same way as applied for steel, the total load in the concrete can be given:

$$(P_c)_T = 2 \left[\sum_{e=1}^{N} (f_{cR})_e (A_c)_e + \sum_{e=1}^{N} (f_{cL})_e (A_c)_e \right] \qquad (16)$$

In the same way as applied for steel, the total moment in the concrete is:

$$(M_c)_T = 2 \left[\sum_{e=1}^{N} (f_{CR})_e (A_c)_e (Z_c)_e + \sum_{e=1}^{N} (f_{CL})_e (A_c)_e (-Z_c)_e \right] \qquad (17)$$

F - FIRE RESISTANCE RESULTS:

The influence of fire on the temperature history of the steel and concrete is mathematically tested for cylindrical reinforced concrete columns. The influence of the cross-section area and the number of reinforcing bars were also examined.

Figure (3) represents the temperature/time relation for the surface of concrete and for the reinforcing bars for cylindrical reinforced concrete column (12.0 in) diameter with (8) reinforcing bars.

It is clear from Figure (3) that the heat transferred from the fire to the steel and concrete is in accordance with the classical solution of the unsteady state partial differential equation [10].

Figure (4) represents the total load/fire resistance relationships of cylindrical reinforced concrete columns of 12.0 in, 14.0 in and 16.0 in diameters with 8 reinforcing bars. From this Figure it is clear that fire resistance of a column will increase by increasing the cross-section area of the column.

The variation of the cross-section area shown in Figure (4) has more influence on the fire resistance than the variation of

the number of reinforcing bars shown in Figure (5). However, the predicted fire resistance of these mathematical models do appear to be of the right order of magnitude based on general experience It is however, fully acknowledged that experimental studies are needed before the sensitivity of these models can be assessed.

CONCLUSION:

In conclusion we can say that: based on the mathematical model calculations of both the heat transfer and mechanical strength, circular composite concrete column will stand at high elevated temperatures.

Increasing the diameter will also mean increasing the allowable load, increasing the time until collapse and change the column characteristics tremendously.

In real life application the design of nuclear-reactor like structure requires the safest design under extreme heat and loading conditions. The gain in time to delay any structure failure is necessary to prevent major nuclear accident and/or nuclear leak and/or to resume normal operation after malfunction.

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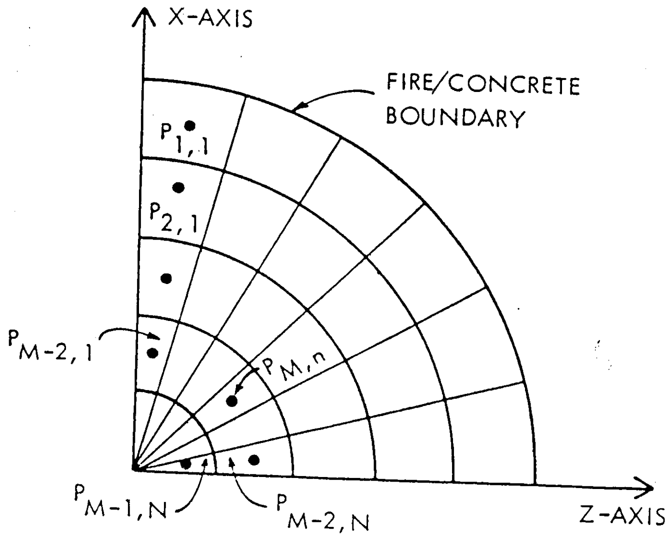

FIGURE 1.

ARRANGEMENT OF ELEMENTS IN QUARTER SECTION OF REINFORCED CONCRETE COLUMN

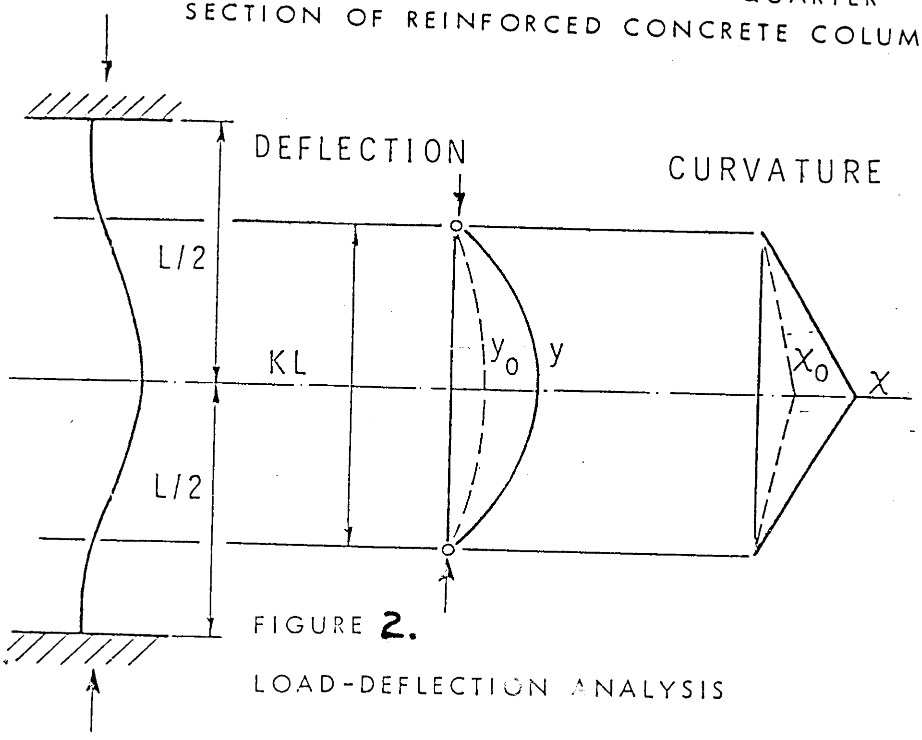

FIGURE 2.

LOAD-DEFLECTION ANALYSIS

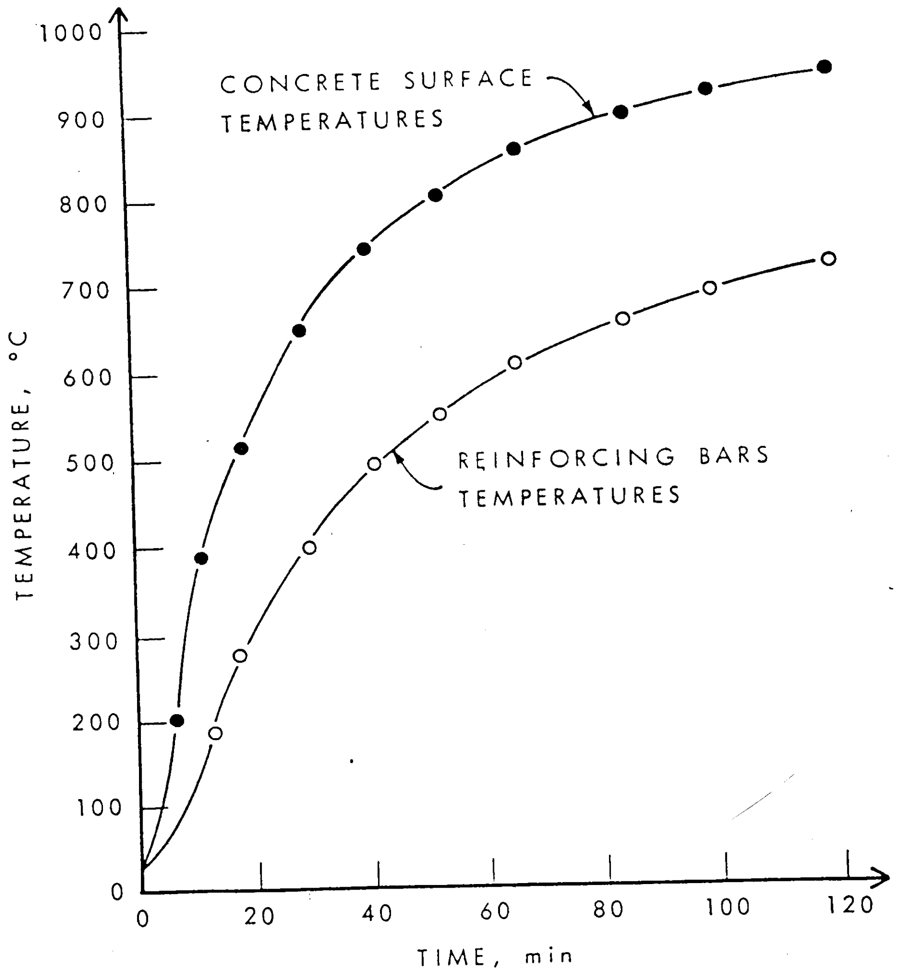

FIGURE 3.

REINFORCING BARS AND CONCRETE SURFACE CALCULATED TEMPERATURES FOR CYLINDRICAL REINFORCED CONCRETE COLUMN (12" DIAMETER AND 8 REINFORCING BARS)

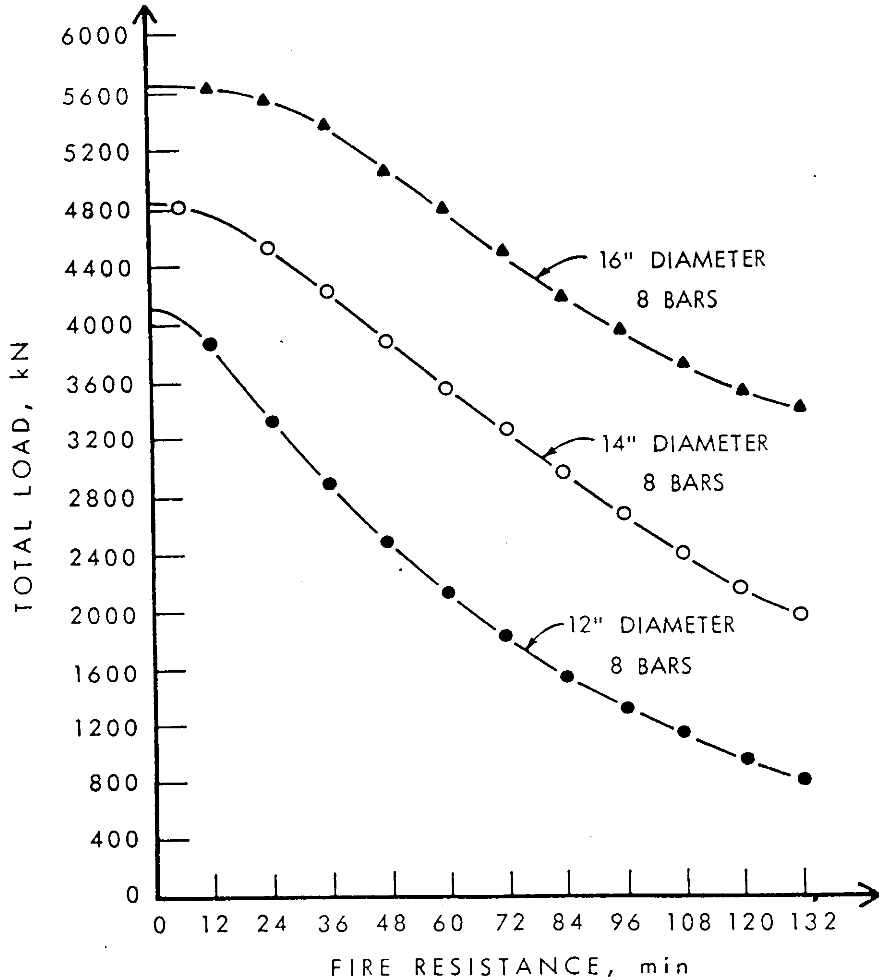

FIGURE 4.

INFLUENCE OF LOAD ON FIRE RESISTANCE FOR VARIOUS DIAMETERS OF CYLINDRICAL REINFORCED COLUMNS (8 REINFORCING BARS)

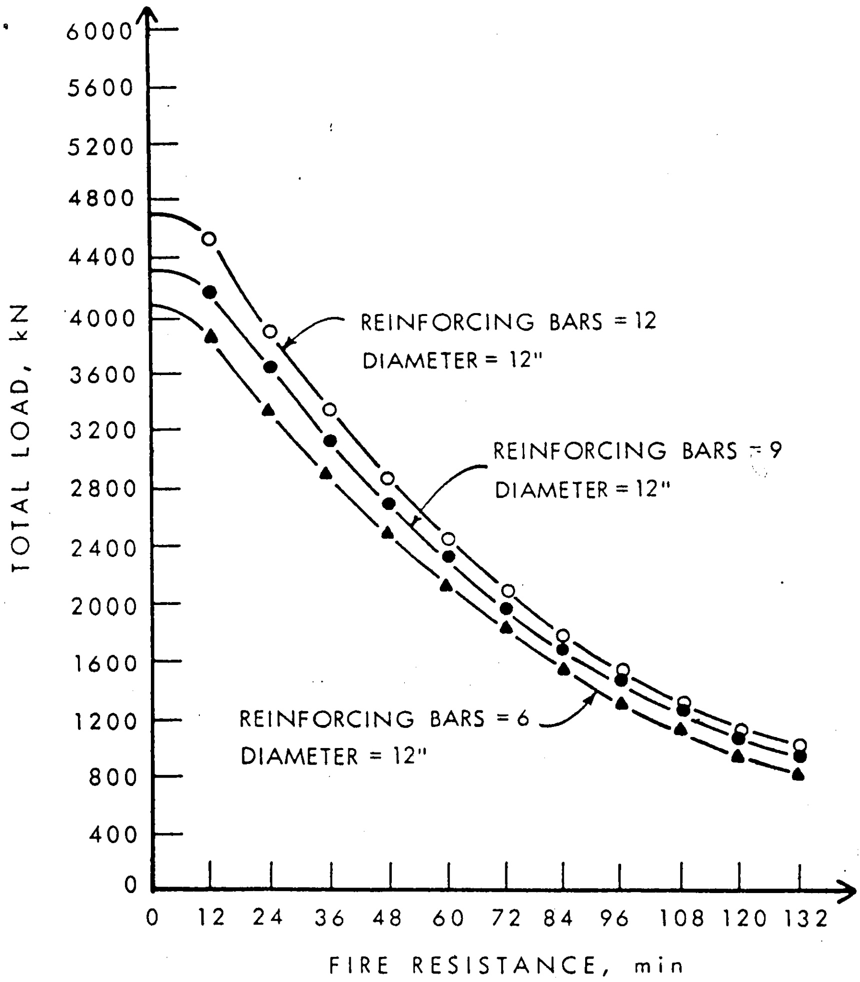

FIGURE 5.

INFLUENCE OF LOAD ON FIRE RESISTANCE FOR VARIOUS NUMBER OF REINFORCEMENT OF CYLINDRICAL REINFORCED CONCRETE COLUMNS (12" DIAMETER)

PART 4

OTHER FORMS OF ENERGY

Biomass Consumption Trends and ICAITI Promotion of Fuelwood Conservation in Central America

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Abstract: Biomass represents 65% of all energy consumed in Central America. Most biomass consumption is very inefficient, providing opportunities for significant economizing through improved technologies and processes. The main biomass fuel is wood which serves as a cooking fuel for 70% of the population. The Central American Research Institute for Industry has investigated, developed and introduced many new technologies, resulting in over 200,000 cubic meters of fuelwood savings since 1980.

1. INTRODUCTION

The Central American Research Institute for Industry (ICAITI) was established over 30 years ago by the five Central American Republics with support from the United Nations. ICAITI is an independent, non-profit organization whose activities have concentrated in, but are not limited to, Central America. The Institute's global mandate is to promote economic and industrial development through the appropriate utilization of the region's natural resources. In addition to its headquarters in Guatemala, ICAITI presently maintains offices in Honduras, El Salvador, Nicaragua, and Costa Rica. ICAITI's objectives include: the preparation of industrial feasibility studies; assistance to the private sector with production problems, investigate use of regional raw materials and by-products, develop new production methods, and adapt improved technologies; establish standards for raw materials and finished products and conduct quality control procedures and trials; and cooperate with the various offices of the governments of the isthmus, universities, technical organizations and other entities.

The Institute presently maintains a staff of 175 people, over half of which are professionals and technicians. The central facilities in Guatemala City include a microbiological

research center; organic and inorganic chemistry laboratories; pulp and paper pilot plant; food technology laboratory; the stove and combustion technology lab; and one of the best technical libraries in the region, with over 55,000 entries, subscriptions to 150 technical periodicals, and computer access to international data bases for information searches.

In the private sector, ICAITI responds to specific requests for technical assistance and executes contracts for quality control. As a result of its applied research, ICAITI holds numerous patents. The Institute also responds to the requests of government agencies in the region, providing technical assistance and services.

ICAITI has implemented projects under contract with international organizations such as AID, GTZ, OAS, IRDC and IDB. The variety among ICAITI projects has been significant. Analysis of environmental and human health impacts of pesticide use in Guatemala; the development of a small, low-cost ceramic filter for purifying water in rural areas; low-cost construction materials using vegetable wastes; and a program to promote industrial energy conservation, are but a few examples.

By the mid 1970's, growing problems were evident in terms of deforestation and the increasing costs for fuelwood on which the majority of the Central American population depended as a primary energy source. In response to these problems, ICAITI signed a Project Agreement with AID in 1979 to execute the Fuelwood and Alternative Energy Sources Project. The Institute's mandate - to promote the appropriate use of natural resources and to develop or adapt technologies for the needs of the region - fit the project objectives well.

2. BIOMASS AND FUELWOOD CONSUMPTION TRENDS

In general, factors such as the petroleum crises of the past two decades, burdensome foreign debt, and economic contraction since 1978, have all contributed to a dualistic society in Central America with a heavy dependence on biomass as a primary energy source. The Latin American Economic Commission (CEPAL) has noted that 60-70% of the Central American population lives in poverty; this means that they are unable to adequately satisfy their basic needs [1]. An equal percentage of the population depends upon fuelwood for energy, primarily for cooking.

Data regarding biomass and fuelwood consumption for the region are presented in Table 1 along with other economic development indicators. The wide variance between the social, economic, and energy situations in the different countries of the region is evident by comparing the statistics of the high and low country in each instance.

Biomass (mostly firewood, plus some charcoal and agricultural wastes) remains the predominant fuel in the region, representing 65% of all energy consumed. Wood alone represents 57% of total energy consumption; sugarcane bagasse is the other primary biomass fuel.

TABLE 1: Economic Development and Energy Consumption Statistics for the Central American Isthmus

	Total Isthmus	High/Country		Low/Country	
Population Density (persons/km2)	49	230	El Salv	23	Nicaragua
Households w/ Electricity % (1984)	38%	85%	C. Rica	25%	Hondur.
1984 Per Capita GDP (1982 $US)	$1,128	$1,998	Panama	$626	Hondur.
Biomass Consumed/Capita (BEP/yr)*	2.3	2.7	Guatema	1.4	Panama
Commercial Energy/Capita (BEP/yr)*	1.3	2.9	Panama	.8	El Salvador
% Biomass of Total Energy (1984)	65%	76%	Guatema	32%	Panama
% Firewood of Total Energy (1984)	57%	72%	Guatema	25%	Panama
Forest Cover (% 1983)	37%	54%	Panama	6%	El Salvador
Annual Deforestation Rate (% 1981)	1.2%	2.4%	Hondur.	.2%	El Salvador
Population Growth Rate (% per yr)	3.0%	3.5%	Nicarag	1.8%	Panama
Firewood Consumption Growth Rate % (annual compounded rate 1978-83)	2.7%	4.8%	Guatema	-.1%	C. Rica
Firewood Users (% of Population)	69%	77%	Guatema	40%	Panama
Firewood Consumed/User (BEP/yr)	3.0	3.5	Nicarag	2.5	Hondur.
Firewood Costs in Urban Centers:					
US$ per cubic meter in 1980	$10.29	$22.00	El Salv	$4.40	Panama
US$ per cubic meter in 1987	$21.10	$40.00	El Salv	$7.50	Panama

* BEP = Barrels Equivalent of Petroleum
Source: ICAITI, Ref. [2]

Fuelwood costs per cubic meter in urban centers have risen sharply in recent years. Prices varied in 1980 from US$4.40 in Panama to $22.00 in El Salvador; 1987 prices have nearly doubled in US dollar terms, running between $7.50 and $40.00 for the same two countries.

Most importantly, the consumption of fuelwood continues to grow at a rate of over 2% per year, despite increasing scarcity and rising prices. Nearly 70% of the total population of the region continues to use firewood and no major reduction in fuelwood consumption rates during the remainder of this century are foreseen.

At present, about 90% of all households in Costa Rica have access to electricity compared with only about a third of the population in El Salvador, Honduras and Guatemala. Despite this fact, roughly half of Costa Rica's population continues to use wood for fuel.

El Salvador is one of the most densely populated countries in Latin America, with an average of 230 persons per square kilometer, and over 70% of these people depend upon wood for fuel. The country was once covered with lush jungle and forest; now less than 6% of El Salvador's national territory is forested. The situation in El Salvador is critical: annual

biomass consumption is greater than total existing annual production including all natural regeneration. If this trend continues, the process of deforestation will soon be complete, aggravating existing problems of high fuel costs for the poor, decreased agricultural productivity due to soil erosion, flash flooding and prolonged droughts, and reduction in productivity and useful life of hydroelectric investments.

As noted, the wood-consuming population in the region coincides with the population living in conditions of poverty. In the four northern countries of the region, over 75% of the population still cooks with fuelwood. About 90% of these people cook on open fires which are inefficient and have negative impacts on health and the environment. Although the severity varies, the problems of deforestation and high dependence on increasingly scarce and costly wood for fuel, are a reality throughout the region.

Studies done both in the region and on a global scale have noted that most wood users would prefer to cook with high quality, convenient fuels such as LPG but are restrained primarily by economic (income & cash flow) and market (distribution & access) factors. Any program which attempts to promote the transfer from wood to petroleum derived fuels (kerosene, propane, etc.) would face certain opposition and could have profound long-term repercussions on the national economy since these fuels are nearly 100% imported. The experiences of other countries leads to the conclusion that a majority of the population will continue to cook with wood and biomass fuels as long as income levels remain low, despite the increasing difficulties of gathering fuel and even eventual establishment of desert conditions.

Effective solutions for the macro problems of economic growth and income distribution are far from realization and even if these problems are resolved, distribution and supply limitations will continue to deter the market penetration of modern, imported fuels. Therefore, more immediate solutions for the poor are necessary which will reduce the burdens of fuelwood collection and purchase, and diminish the health and environmental problems related with inefficient biomass combustion.

3. THE FUELWOOD AND ALTERNATIVE ENERGY RESOURCES PROJECT

The overall goal of the project was to improve the welfare and productivity of low income groups through the provision of appropriate energy technologies. Given ICAITI's strategic position as a regional research and coordinating institution with relatively limited field capacity, the project defined its role as that of a second-line institution; to take the lead in research and investigation and then train and coordinate with national organizations to test and provide the improved energy-efficient technologies for use in rural areas. The technologies were to include domestic and small industry applications. The project was organized into three groups: solar applications, biogas and combustion.

3.1 Evolution of Improved Stove Activities

Given the project's purpose, this was perhaps the most important component. Stove activities initiated with an investigation of the cooking practices in the region and of the traditional stoves being used and built. A great deal of variety exists among the stoves and foods of Central America. In the market places of Central America, many wood stove options are available, but they tend to be either very expensive (such as the cast iron models) or very inefficient, such as those made from scrap metal and 55 gallon drums.

ICAITI also researched the state of the art of improved cookstoves throughout the world (as of 1980). Based on both the regional field research and the information obtained regarding other designs around the world, 16 models were selected for detailed study. It was necessary to develop a valid and workable methodology to evaluate the comparative efficiency of the stoves since no standards or examples were readily available at this time. The methodology developed included a water boiling test conducted by ICAITI technicians and practical cooking tests where local housewives used the different models cooking typical foods. Based on the results of these tests, the five best stove models identified were the Lorena, Chula, Singer, Block and Adobe [3].

A regional field study of these five stove models was organized involving 450 stoves, 75 in each of the five participating countries. In each country, the National Planning Office of the host government helped ICAITI select counterparts which included PVO's and public institutions. Extensionists from each participating institution were trained in stove construction and in the survey techniques to be utilized. The stoves were distributed to cover the diverse ethnic, social and geographical conditions present. The results and conclusions of the field tests can be summarized as follows:

- Average stove life was estimated to be 3 years, but there was a wide degree of variation.

- The stoves were accepted by the vast majority of housewives: 70% of the stoves were in daily use and 50% of the users did not encounter any problems with the stoves.

- The determining factors for acceptance were: cooking convenience, improved kitchen environment/smoke removal and prestige (not fuel economy).

- Fuel savings compared with the traditional fire were disappointing and inconsistent. Too often, the new stoves appeared to consume more fuel than the traditional fires. On average, fuel savings in the field were calculated to be 15% but with a large sample deviation.

- The principal causes for the significant variation were improper construction and improper use.

As a result of the field evaluations of the five models, ICAITI began to investigate new designs which would be more repeatable, more consistent in fuel savings, and which would facilitate the rapid and massive diffusion of improved stoves. After considering various options, ICAITI developed an improved stove which is built using pre-fabricated ceramic pieces. This model offers the following advantages over the previous designs:

+The pre-fabricated design avoids the problems of construction by owners and facilitates proper installation.

+It can be produced by artisans using local technology and materials.

+The design was adapted to fit the needs of the majority of rural households in Central America.

+The identification and preparation of special materials (clay/sand mix) by owners is not necessary. Average construction time is much less than that of the lorena.

+The stove can be used almost immediately upon completion (you do not have to wait a month for it to "cure").

+The cost is comparable to the other stoves (US$ 15-30, depending upon the materials used for the base, chimney and stove finish). When labor is considered, the ceramic stove is usually cheaper than the other stove models tested.

+The benefits of prestige, smoke removal, and cooking convenience are maintained and improved.

+Fuel savings are higher and much more consistent: 34% on average with a sample variance of 15%. Fuel savings are appreciable even when the stove is operated improperly.

In 1986, the ceramic stove was introduced by ICAITI throughout the region by providing a few demonstration models to interested institutions and by training ceramists in the construction of the pieces (special molds and forms have been devised for each piece which facilitate training and quality control). No funds have been provided for a promotional campaign nor to support commercialization of the product by artisans. Despite these limitations, results with the ceramic design are promising. Dissemination has been rapid: over 4,000 of the new ceramic stoves were put into use in the region, some 3,500 in Guatemala alone, in less than two years. The majority of these have been sold through the initiative of the ceramists themselves, indicating that there is high potential for mass dissemination of the technology at a low cost. To date, about 100 ceramists have been trained in stove manufacture in Guatemala and about half of these are selling the pre-fabricated stoves as a principal product.

Fuel savings with the ceramic stove have been consistently high. Independent evaluations found fuel savings to be 34%.

The evaluations also found that most owners were capable of correctly installing the stove with minimal previous instruction. A major benefit of the ceramic stove design is that it has significantly increased the income levels of the rural artisans who build and sell the pieces. The pre-fabricated model uses 100% local materials and has also begun to create employment for people specializing in commercialization and installation.

Recently, ICAITI began collaborating with local institutions to focus on the needs of urban fuelwood users. Large numbers of fuelwood users are concentrated in urban and semi-urban areas where the effects of fuelwood demand on the environment (deforestation and erosion) and household economics (most wood is purchased) are much more critical than in rural areas. For example, some 400,000 people are living in extreme poverty in shanty towns around Guatemala City and nearly all use wood for cooking. Studies in these areas encountered average incomes of US$37.00 per month and cases where 30% of this was being spent on firewood.

3.2 Other Fuelwood Project Activities

Since 1980, the project has developed a series of designs for rural industries which save fuelwood and/or employ alternative fuels such as biogas and solar energy. Over 100 different applications have been tested. Of special interest are the industrial and institutional stoves which have had a high rate of acceptance and have been consistently successful in saving fuel.

The industrial stoves are generally made of brick and tend to be used for an identical process day after day. The stoves are usually designed to fit the pots and the process (cooking demand), and customizing under these circumstances is much more convenient than in the domestic models where different pots and processes are regularly employed. In El Salvador, a model for tortillas has been very successful and is self-disseminating. That design has also been adapted to coastal preparation of cassava. Similar stoves have been built and demonstrated in restaurants, schools, refugee camps, hospitals, and women's cooperatives making jams and fruit preserves. The stove is now being used in over 30 small food processing businesses in the region. Specialized masons are normally employed for the construction of the stoves.

Some other designs developed by the project are:

- A bread oven which saves 30% of the fuel used by traditional designs (47 units in use, mostly in El Salvador);
- An improved kiln for bricks and roofing tiles which offers 45% fuel savings;
- Solar salt technology which has saved thousands of acres of mangrove swamps (especially in Honduras and Guatemala);

- Charcoal kilns which are both 35% more energy efficient than traditional methods and permit the utilization of the refuse materials remaining after tree harvesting for lumber (over 30 units in use in Costa Rica);

- Crude sugar ("panela") evaporators which use cane stalks for fuel (promoted in Panama where the artesan crude sugar industry traditionally used wood);

- Solar lumber kilns and agricultural dryers; and

- Hybrid dryers which combine solar and other energy sources for consistent drying times and quality; for agricultural products (fruit, grain, coffee, cacao) and other uses.

4. PROJECT RESULTS

The Project was completed in December 1987 and the final evaluation found that it had met or exceeded programmed outputs at less than programmed cost [4]. Project impacts include 13,000 beneficiary households, with primary beneficiaries being rural women; the employment of over 1,500 people, especially in new industries such as solar salt; and 200,000 cubic meters of fuelwood directly conserved as a result of the adoption of the technologies promoted. In addition to the fuelwood savings, solar applications and biogas have been utilized in small rural industries representing new sources of power with energy values equivalent to another 400,000 cubic meters of fuelwood. Of the more than 25 technologies and 100 applications investigated, the most successful were: solar salt production, lumber drying, charcoal and brick manufacture, bread ovens and wood burning stoves (both industrial and ceramic domestic). Highlights of the evaluation findings are summarized in Table 2.

The project has trained or worked with over 400 different groups in the region. These institutional contacts provide ICAITI with a valuable resource for future activities. As an independent, regional organization, ICAITI has been able to successfully coordinate similar actions with many diverse groups in each country, something which is often difficult to realize through national organizations alone.

ICAITI has distributed over 68,000 publications related to the new technologies. A list of over 60 biomass technology publications is available from ICAITI. Although the Project has ended, ICAITI continues to provide services on a user-fee basis.

5. OTHER ACTIVITIES WITH BIOMASS

Sugar cane (bagasse) energy potential in the region was recently examined by the Institute. The bagasse is presently under-utilized as common processing techniques are designed to incinerate the residues to avoid disposal costs. The potential for electricity production (and sales) through cogeneration is significant and could provide the sugar cane growers a new area of diversification.

TABLE 2: ENERGY-SAVING DESIGNS DEVELOPED BY ICAITI
STATUS & IMPACTS

ICAITI Component & Process	Models	--UNITS BUILT & IN USE-- w/ICAITI Support	Total Built	% In Use	F-WOOD CONSERVED M3	JOBS CREATED
Combustion						
Bread Ovens	Batch Oven	26	47	74%	1,300	75
Brick Kilns	PTR adaptation	1	8	88%	100	30
Ceramic Kiln	Low-Cost Batch Kiln	4	8	75%	NA	NA
Charcoal Kilns	Modif. Beehive (Brazil)	1	35	91%	9,500	50
	Portable Metalic	2	2	50%	100	1
Crude Sugar Prod.	Bagasse Fired (Guate.)	9	9	67%	600	20
	Combustion Subtotals:	47	107	80%	11,600	176
Cook Stoves						
Semi-Industrial	"Institutional" Stoves	21	43	81%	800	75
Domestic	Lorena & Similar Designs	4,200	16,550	69%	62,100	10
	Pre-fab. 3-H Ceramic	1,060	4,190	91%	10,640	150
	Cook Stove Subtotals:	5,281	20,783	74%	73,540	235
Solar						
Lumber Kiln	Solar & S/C, Various size	11	11	100%	0	55
Agric. Dryers	Various	61	72	18%	500	50
Salt Evaporation	Black Plastic	12	142	96%	100,000	1,200
Water Heating	Primarily flat plate	4	4	75%	0	NA
	Solar Subtotals:	88	229	64%	100,500	1,305
Biogas						
Anaerobic Digest.	Low Cost Digestor	21	22	23%	75	0
Anaerobic Digest.	Conventional Digester	48	54	50%	810	2
Anaerobic Digest.	Dry Digester	1	1	100%	5	0
	Biogas Subtotals:	70	77	42%	890	2
Others						
Agric. Dryers	Solar/Combustion	4	4	75%	100	15
Others	Various	48	42			6
	TOTALS	5,534	21,244	74%	186,630	1,739

Source: Independent Evaluation, 1987; Ref. [4].

The five Central American republics currently process nearly 19 million metric tons of wet cane per season. The total potential energy from this resource exceeds 2.8 million MWh per year, or nearly 30% of total electricity generated by the utilities of the region at present.

ICAITI also developed and patented a unique fuel alcohol process for the production of ethanol from sugar cane (the EXFERM process). There are presently three ethanol plants in the region using traditional processes with a combined production capacity of 420,000 liters per day.

The utilization of the region's most common agricultural wastes for energy and other by-products is a continuing research priority. Methane production, direct combustion, gasification and other uses have been investigated. Recent projects focus on coffee and banana plantation wastes. The application of anaerobic digestion technology for the treatment of industrial wastes is another area where ICAITI is currently active, for example, assisting distilleries in the region with the processing of spent slops and the production of methane.

Given its mandate and historical role in the region, ICAITI will continue to work to support the best utilization of the region's biomass and energy resources.

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ICAITI's Regional Industrial Energy Efficiency Program (PEEIR)

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Abstract: The Central American Research Institute for Industry (ICAITI) conducted a regional program to promote energy conservation in the industrial sector from 1983 to 1988. The main components of the program were energy audits, technical publications and the training of engineers and plant technicians. Through widespread promotional activities, the program succeeded in achieving its objectives. To date, the region's industrial sector is accruing benefits at an estimated rate of US$ 5.5 million per year due to the energy-saving measures implemented by industries as a result of ICAITI activities. Total accumulated savings for the region presently surpass US$ 16 million and continue to grow. This more than justifies total program related investments of less than eight million dollars.

1. INTRODUCTION

The Central American Research Institute for Industry (ICAITI) was established over 30 years ago by the five Central American Republics with support from the United Nations. ICAITI is an independent, non-profit organization whose activities are concentrated in Central America. The Institute's global mandate is to promote economic and industrial development through the appropriate utilization of the region's natural resources. In addition to its headquarters in Guatemala, ICAITI presently maintains offices in Honduras, El Salvador, Nicaragua, and Costa Rica. ICAITI's objectives include:

- -Assist the private sector with production problems, investigate use of regional raw materials and by-products, develop new production methods, and adapt improved technologies. Food products, leather, wood, anc agricultural wastes have been areas of extensive research.

-Establish standards for raw materials and finished products and conduct quality control procedures and trials.

-Prepare industrial feasibility studies. Examples range in scope and complexity from an international gasahol industry to small, individual, artisan businesses such as rural bakeries.

-Cooperate with the various offices of the governments of the isthmus, universities, technical organizations and other entities.

The Institute presently maintains a staff of 175 people, approximately half of which are professionals and technicians. The central facilities in Guatemala City include a microbiological research center; organic and inorganic chemistry laboratories; pulp and paper pilot plant; food technology laboratory; the stove and combustion technology lab; and one of the best technical libraries in the region, with over 55,000 entries, subscriptions to 150 technical periodicals, and computer access to international data bases for information searches.

In the private sector, ICAITI responds to specific requests for technical assistance and executes contracts for quality control. As a result of its applied research, ICAITI holds numerous patents. The Institute also responds to the requests of government agencies in the region, providing technical assistance and services.

ICAITI has implemented projects under contract with international organizations such as AID, GTZ, OAS, IDRC and IDB. The variety among ICAITI projects has been significant. Analysis of environmental and human health impacts of pesticide use in Guatemala; the development of a small, low-cost ceramic filter for purifying water in rural areas; low-cost construction materials using vegetable wastes; and a program to promote appropriate technology in rural areas; are but a few examples.

The oil crisis of the 1970's was exacerbated by growing political turmoil and economic recession throughout Central America in the 1980's. The importation of petroleum represented and still represents a significant portion of the region's foreign debt. Likewise, the industrial sector was generally an important and inefficient consumer of petroleum derived fuels, relying upon equipment and technology dating from the 1950's. In response to these problems, ICAITI established the Regional Program for Industrial Energy Efficiency, known as "PEEIR" for its Spanish acronym.

2. PETROLEUM IN THE CENTRAL AMERICAN ECONOMY

From the mid 1960's through the late 1970's, the Central American economies grew robustly, being fueled by industrial development, a dynamic regional common market, foreign investments and favorable credit. During this period, energy consumption, and petroleum imports in particular, grew rapidly.

Since the oil crisis at the turn of the decade, the quantities of petroleum imports have dropped while costs for imports have skyrocketed.

After the 1979/1980 oil crisis, the economy of Central America entered its worse era since the depression of the 1930's. The overall balance of payments deficit had jumped from $320 million in 1979 to $1,130 million in 1980. The single most important factor behind the economic crisis was considered to be the cost of petroleum imports which mushroomed from $101 million in 1973 (representing 6% of total exports) to $1,077 million in 1981 (22% of export earnings). The consequences of this economic turmoil included political unrest, massive capital flight, the disappearance of private investment, accelerated increases in foreign debt and government budget deficits, and the collapse of the Central American Common Market. Under these circumstances, the reduction of the foreign exchange deficit became a top priority. Since 97% of the oil consumed in the isthmus was being imported, a reduction in oil imports became a key regional objective.

The governments of the region responded by initiating an intensive program of large hydroelectric power developments in order to reduce petroleum requirements for electrical generation. The next easiest sector for reducing petroleum consumption was industry. Although transportation has been the most important oil consumer representing about half of all imports, no easy and rapid solutions were evident for substituting for oil and diesel in this sector. The industrial sector, however, offered significant potential for cost-effective reductions through improved efficiency.

Table 1 presents the distribution of petroleum use by sector for 1978 and 1985.

TABLE 1: PETROLEUM USE BY SECTORS 1978 & 1985

Sector	1978	1985
Utilities	22%	11%
Transport	43%	58%
Industry	24%	18%
Residential, Commercial and Public	9%	10%
Other	2%	3%
	100%	100%

Sources: AID for 1978, Ref. [1]; SIECA for 1985, Ref. [2].

By 1978, industry in Central America had become a major consumer of petroleum, both directly (24%) and indirectly (an additional 9% for a total of 33% of all petroleum imports) due to its share of thermal-electric consumption. The price changes and programs carried out in Central America over the past decade to promote conservation and substitution have resulted in a redistribution of petroleum consumption by sector, with the shares for thermal electric production and industry falling relative to the transport and residential sectors.

Given the important role of industry in the economic development of Central America, the PEEIR energy conservation program was initiated.

3. DESCRIPTION OF THE PEEIR CONSERVATION PROGRAM

The PEEIR was formally established in July, 1982 and received financing from the U.S. Agency for International Development until 1988. The overall objective of the project was to reduce the economic deficit of the region by increasing the efficiency of the region's industrial sector, thereby reducing the consumption of imported petroleum per unit of production.

The principal activities were aimed at improving energy efficiency in medium sized industries throughout the region. To this end the project introduced: a) energy audits; b) plant level energy conservation programs; c) direct promotion and demonstration of more energy efficient processes and equipment; d) courses to train plant technicians and engineers in topics ranging from more energy-minded operation and maintenance procedures to more extensive training as energy auditors; and e) technical publications and newsletters promoting energy efficiency in some of the most common areas for improvements (boilers and steam systems, for example).

The programmed outputs for the Project are compared with those actually executed in Table 2. In most instances the programmed outputs were achieved or exceeded.

TABLE 2: ICAITI PEEIR OUTPUTS 1983-88

Activity	Total Planned	Total Achieved
Seminars and courses	50	69
Energy audits		
Level I	150	132
Level II	100	114
Auditors trained	200	240
Promotional conferences	20	30
Promotional visits	400	499
Publications	87	90
Audit follow-ups	250	250
Equipment Demonstrations	80	76

Source: Independent evaluation, 1987, Ref. [3].

The Project progressively developed a cadre of highly-qualified energy auditors and trainers. ICAITI established a mailing list of over 4,000 representatives of the private and public sectors who had contact in one form or another with the PEEIR. The Project worked closely with the private sector and maintained a formal relationship with the Chamber of Industry in each country.

3.1 Seminars and Courses

A series of specialized seminars and courses were adapted to the needs of Central American industries. ICAITI personnel prepared technical materials, manuals, visual aids and made initial presentations to ICAITI staff as a part of the preparation process. Then most seminars were presented in each of the participating countries. Due to demand, some seminars and courses were presented more than once. Seminar participants typically paid $40-75 to help offset ICAITI expenses. Table 3 provides a list of the seminars and the number of presentations made for each type of course.

TABLE 3: ENERGY CONSERVATION SEMINARS AND COURSES

Seminar	No. of Presentations
Boiler Efficiency	19
Conservation of Electricity	10
Energy Management	6
Measurement Equipment and Techniques	6
Steam System Efficiency	6
Energy Savings in Buildings	6
Combined Seminar (touching on all of above)	1
Energy Savings in Cement Industries	1
Cogeneration	1
Course for Energy Auditors	11
Course for Plant Technicians	2

3.2 Energy Audits

ICAITI executed two types of energy audits. A "Level I" audit was a simple walk-through audit which identified the most visible and easily implemented opportunities for energy conservation. This type of audit was initially used to help train personnel, to introduce the idea of energy audits to industry, and to promote the sale of a more in-depth, Level II audit to clients. Level I audits were conducted without charge up until the final year of the project. During the life of the Project, 132 Level I audits were conducted, nearly all of them in the first two years of activities (1984-85). On average, this type of audit identified cost-effective opportunities for saving 5% of the total energy consumption of a given industry (with a mean pay back period on investment of six months) .

Level II audits were much more comprehensive and time-consuming than Level I. A detailed report was produced as

a result of these audits describing each type of energy saving investment identified, the investment costs compared to the expected savings, and ICAITI recommendations for the most cost-effective opportunities (usually those with the shortest pay-back periods). In the initial years of the Project, ICAITI charged 0.5% of the energy bill of the factory audited, with a minimum charge of US$500 and a maximum of $2,500. This did not recover the total direct costs of the audit in most cases, however, and in the final year of the project ICAITI tried to begin charging the full direct costs estimated to be necessary to carry out the audit. Even after this method was initiated, in practice, only about 60% of the total costs were recovered.

ICAITI trained 210 plant engineers to carry out Level II audits in their own factories. ICAITI also directly carried out 114 Level II audits, recommending effective options for reducing total energy costs by about 10% per industry (double the average savings identified in Level I audits). Information regarding the opportunities for energy conservation identified are summarized in Table 4 below.

TABLE 4: POTENTIAL ENERGY SAVINGS IDENTIFIED IN AUDITS

	Level I	Level II	Total
Industries Audited by ICAITI	132	114	246
Annual Energy Costs of Industries Audited (US$ x 1000)	31,154	37,804	68,958
Potential Savings from Opportunities Recommended (US$ x 1000)	1,645	3,561	5,206
% Savings (savings/costs)	5%	9%	8%

The most common types of energy saving opportunities identified were related with plant operation and maintenance. This is because these were the easiest and cheapest to implement resulting in rapid pay-back of the investment. Improved lighting systems, improved insulation, improved combustion efficiency and minor corrections or improvements to steam systems were the most frequent recommendations made to industries.

3.3 Publications

The project prepared a wide variety of publications to help improve energy efficiency in the industrial sector. Perhaps the most popular was the "Energygram", a monthly newsletter with basic energy conservation tips and short case studies of successful energy-saving applications. Over 3,000 businesses and groups received the Energygrams; 46 different issues were published.

The Project also published 16 promotional and informational bulletins, 9 different pamphlets, numerous posters, technical video-tapes, case studies, and internal progress reports.

4. PROJECT IMPACTS

A final, independent evaluation of the Project concluded that it had met or exceeded its objectives at less than programmed costs. The most important impacts are the improvements in energy efficiency actually realized as a result of the Project. In order to measure the real impacts more objectively, the Project contracted an outside firm to survey industries in each of the participating Central American countries to see what the results of the audits, training and publications were in terms of dollars saved through improved efficiency.

The surveys were conducted in 1986 and 1987 by making visits and interviewing officials at 137 firms. The surveys confirmed that ICAITI had clearly succeeded in raising the level of consciousness about energy efficiency in the region's industrial sector and in attaining significant economic savings due to increased levels of production efficiency.

Concerning energy audits, although there was a great deal of variation in terms of how many of ICAITI's recommendations a given factory had implemented (ranging from zero to 100%), the survey was able to determine that after one year, the average firm had implemented recommendations representing about 30% of the potential savings identified by ICAITI, and after two years the real savings represented 60-70% of the total potential recommended by ICAITI. The survey also established the average level of savings in US dollar terms which had resulted in the participating industries as a result of the implementation of audit recommendations. The survey results were applied to the total universe of industries to determine the total level of impact on a year by year basis.

The survey also isolated the degree of savings resulting from the participation in courses and seminars, and from the application of information obtained through ICAITI publications. As with audits, the data were then applied to the total universe of beneficiaries to estimate the overall impacts of these activities. The project impacts in all three areas are presented in Table 5. These impacts have been significant.

Over $16 million in savings have accrued as a result of PEEIR activities from 1984-1988. This figure should be compared with the costs to industry, whose investments in energy conservation totaled roughly $ 3.5 million. The net profit for participating industries totals 12.5 million dollars due to savings on energy bills alone. And the savings will continue to accumulate in the future at an annual rate of US$ 5.5 million per year.

While energy audits represent the majority of the savings (60%), they also represented the greatest cost to both the Institute and the industries. ICAITI estimates that the training and publications (which complemented each other) were more cost-effective in terms of impact per Project dollar invested. These two activities also demonstrated the greatest potential for cost recovery.

TABLE 5: ESTIMATION OF REAL TOTAL SAVINGS RESULTING FROM: 1) IMPLEMENTATION OF RECOMMENDATIONS OF ICAITI ENERGY AUDITS; 2) PROJECT TRAINING ACTIVITIES; AND 3) ICAITI PUBLICATIONS.

	Total Annual Savings in US$ x 1000 Resulting From:			
Year	Audits	Training	Publications	Total
1983	13	-	-	13
1984	264	-	-	264
1985	968	402	442	1,812
1986	1,977	793	774	3,544
1987	2,905	999	995	4,899
1988	3,427	1,030	1,105	5,562
Total Accumulated Savings 1983-88:	$9,554	$3,224	$3,316	$16,094

Total PEEIR costs, including foreign technical assistance, training, administration, etc., were $4.2 million. Given the net economic benefits noted above for participating industries ($12.5 million) and the additional benefits related to reduced petroleum imports, improvements in the balance of trade and in foreign exchange, improved competitiveness of industries leading to increased exports, and other secondary benefits such as positive environmental impacts due to improved combustion efficiency and waste disposal, it must be concluded that the program was extremely cost-effective and profitable for the entire region.

5. FINAL CONSIDERATIONS

The Central American economy was in crisis throughout the period of Project execution, and energy conservation was not a priority of the industrial sector. The priority problems for industry in this decade - issues which have threatened its very survival - have been: political instability; the lack of capital and foreign currency necessary for purchasing raw materials and for other investments; national policies and economic difficulties affecting exports, taxes and labor; and market instability. Considering that the costs of energy in relation to total production costs for most industries in the region is very small (5-10%), the possibility of saving a portion of this through improved efficiency was not, in of

itself, sufficient to motivate a large demand for the Program's services. Thus the PEEIR encountered initial resistance and had difficulties selling audits and other services at the beginning of the program.

Despite these obstacles, ICAITI very successfully promoted energy conservation in Central America's industrial sector. This was possible because of a dedicated team and an enormous promotional effort. As noted above, the audits resulted in significant savings for most industries, with an average of about $14,000 in reductions on annual energy bills per industry resulting from investments with pay-back periods typically less than one year. After a few industries participated in the program successfully, it became easier to interest other businesses based upon the results of initial activities. In this way, and with the support of the Chamber of Industry in each country, more and more industries began soliciting services and demand for the program grew exponentially.

Another factor which facilitated the Program's success was the external financing received. Without this support, it would have been impossible to get the program off the ground and to reach the large number of industries which actually benefited from the project. Since external project support is no longer available, ICAITI has begun to promote the sale of audits and other services at a price which will cover the Institute's costs, but it is still too early to draw conclusions about what the result of this strategy will be. One obstacle to the new policy is that the former pricing levels were widely publicized and the industrial sector is reluctant to pay the true costs for services knowing that the services had been available at a much lower, subsidized, rate for a number of years.

ICAITI believes that financing has not been the most important factor deterring the implementation of past audit recommendations. Most industries audited can secure credit for the levels of investment required to implement ICAITI's recommendations (which were purposely limited to low-cost, quick pay-back opportunities). However, it is clear that a special, less bureaucratic line of credit in foreign currency (e.g. US$) for energy conservation could greatly increase the implementation of recommendations and help promote the sale of new audits, especially with smaller firms and industries. It would also make it possible to recommend more substantive changes aimed at major improvements in efficiency through process modifications and upgrading of technology. Therefore, ICAITI is presently working with a regional lending institution to try to arrange this sort of a financing mechanism.

It should also be noted that, although the Program was designed to attend a specific group of medium-sized industries, it has recently begun to respond to requests from other sectors such as large, specialized, energy-intensive industries in the region (sugar, cement, distilleries), the commercial sector (hotels and supermarkets), and even government buildings. Immense potential still exists for energy conservation through improved efficiency, and as the region's economies rebound, there will be a shortage of energy supply.

Many governments are already faced with electrical generation deficits during the dry season with increased problems foreseen in coming years. Improved end-use efficiency and industrial cogeneration represent worthy alternatives to investments in new generating capacity; global experience shows that these energy saving alternatives can be much more cost-effective and beneficial to the national economies than the traditional approach of expanding supply. The governments and private sector in Central America are showing increased interest in these energy efficient options. There remains much to be done.

In conclusion, ICAITI has established procedures and trained personnel to effectively carry out an industrial energy conservation program. The efforts to date have been most successful. The economic benefits to industry thus far have been over two times greater than all Program-related costs (including outside financing, ICAITI costs and investment costs incurred by the industries). More important, these benefits continue to grow at a rate of over $5 million per year. Although other priorities may presently outweigh energy conservation in much of the region's industrial sector, this will charge as fuel prices increase in the future and when the region begins a sustained economic recovery. Then ICAITI and the technicians it has trained will be in an excellent position to provide pertinent technical services in support of energy conservation and in response to the demand of the industries of the region.

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PRODUCTION OF BIOGAS FROM THE WASTE OF ANIMALS

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ABSTRACT :

This article deals with the Tunisian experience in the field of reweble energy,particularly the one of "Entreprise Tunisienne d'Activités Pétrolières" about geothermy and the biomass.

Concerning the last subject, we will go through details in the process of energetic valorization about animal waste by the biochemistry way and its application on the rural scale.

Then, we will present the results of biogas production by fermentation from the poultry waste . Those results will show the importance and originality of starting methodology concerning that fermentation. They will show as well that the poultry waste product 60 % of methane and 0,4 m^3 of biogas per kg of dry organic content.

1. INTRODUCTION

Tunisia must develop a self sufficient and reliable source of energy not to be depending from the economical world context. As for its cost is concerned the energetical problems with which our country will be soon confronted, revealed the importance for Tunisia to dispose about such sources of energy. Geothermy and biomass are not only particularlyoffering these advantages, but are also offering the possibility for the users of perfected proceedings with competitive cost prices in certain cases.

The development of these two forms of renewable energy is supposing that the ressources are well known. For this purpose processing researches related to the potential have carried out in order to decide about the opportunity of using these forms of energy.

As for geothermy is concerned, the geological and hydro-geological processing researches have demonstrated that the geothermal ressources in Tunisia are essentially ressources with low enthalpy owing to fact that the underground temperatures are not exceeding 80 - 100°C up to 2000m depth. The researches which have been carried out up to now in different regions of the country didn't displayed very significative features attesting the presence of vapours on the surface level, but revealed on the other hand the existence of warm water at several places. This water corresponds to the diverse thermal sources (about thirty) which have been recently carried out in the south of the country for agricultural and industrial needs with a warm water production up to 70°C at 2000m depth and to the source wells susceptible to be employed as geothermal wells in case of available recovery. A good deal of these ressources which are already known may correspond in certain cases to consumering energy centers relating to different sectors (agricultural, industrial, residential and tertiary).

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In matter of utilisation and according to the temperature of the ressource, the utilisation possibilities have been subdivided into two parts : application possibilities for ressources with low temperatures : 25 to 40°C (heating of greenhouses, heating in the open fiels, pisciculture) and application possibilities for ressources with low or middle temperature : 40 to 100°C (heating of building, drying of agricultural products, industrial applications and desalinization).
Considering the economically available ressources in Tunisia and the locally utilisation of these ressources, it is possible to confirm that the greenhouses heating and the pisciculture would offer the most promising results.

As for biomass is concerned, and considering the type of waste products and by-products issued from agricultural and agro-food activities, the quantity being recuperable and the corresponding valorising technics, it is possible to estimate the energetical global potential susceptible to be garanted by this biomass to 220.000 T.O.E/year. This potential is essentially issued from following main waste products : effluents and waste products from agro-food industries (70.000 T.O.E./year), animal waste products (130.000 T.O.E/year) and urbain waste products (17.000 T.O.E/year). These objectives can only be reached through an integrated approach involving preliminary studies, research, experimentations and tests, in order to highlight the different obstacles that are encountered at different stages of processing.

We note, that the waste of animals are corresponding to the waste products mainly issued from the cattle and the poultry farming (generally intensive). The available quantities in terms of dry matter are coming to about 750.000 Tons/year for cattles waste products ant to 200.000 Tons/year for manures.

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Concerning this last point, many researches and development projects have been initiated in Tunisia. Among those projects, we can cite the ones of the North West Sylvo-pastoral Office and the "Entreprise Tunisienne d'Activités Pétrolières" (ETAP), concerning biogaz production from cow waste and poultry waste respectively.

2. ENERGETIC VALORIZATION OF ANIMAL WASTE BY THE BIOCHEMISTRY WAY

This technology permits to obtain a methane-rich gas by methanic fermentation process in anaerobic environment. It permits to reach three objectifs :

- To produce a methane-rich gas (60 to 80 %) that may be used as a combustible;
- To gather, after fermentation, an odorless "compost" that may serve as an organic fertilizer in agriculture;
- To clean the environment by reducing the organic waste volume;

3. PRODUCTION OF BIOGAS FROM COW WASTE

Work done in Sejnane by the North West Sylvo-pastoral Office, with collaboration of Germany Cooperation and the National School of Engineers of Tunis (ENIT), for the fabrication of small digestors in isolated farms (type "DOME"), has permits to specify the conditions and the performances of cow waste fermentation.

This technology started after the massive deforestation of the Sejnane region hnown for having dense forests and a breeding tradition (cows, sheep and goats).

3.1. Demonstration plant (fig.1)

The cow waste is daily injected in an alimentation reservoir where it is diluted at 10 % of dry matter.

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By gravitation system, this quantity is injected in the digestor for the fermentation.

At the same time, an equal amont of fermented cow waste is evacuated from the digestor (communicating vases principle). During the fermentation, the biogas produced is stored, then used in the farm.

The development of this type of installation in the rural zones, does not need any specific know-how. The construction is simple. However, the exploitation of this installation needs a continued surveillance, especially about the quality of the biogas produced and the agitation mode. In the other hand, this installation can not work at the optimum conditions when the digestor temperature is not constant ($\simeq$ 35°C) due to the variation of the outside temperature.

3.2. Gas production rate

Each digestor having a 16 m^3 volume, produces 5 m^3/day of biogas, corresponding to 1 m^3 per day and per cow. This quantity of biogas is enough for the energetic needs of the farm (2 to 3 m^3/day).

3.3. Use of the biogas produced

The biogas produced contains 50 to 60 % of methane. It is used directly in the farm for cooking with a standard cooker, and for lighting with specificly designed lamps.

The biogas consommation is for :
- Cooking : 150 liters per hour ;
- Lighting : 60 to 70 liters per hour and per lamp (equivalent to a lamp of 60 W).

3.4. Use of the fermented cow waste

The effluent that is evacuated from the digestor after fermentation is directly used as an organic fertilizer in the agriculture. The quality of this product satisfys

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the farmers needs.

4. PRODUCTION OF BIOGAS FROM THE POULTRY WASTE

In Tunisia, the potential of the manures is important (200.000 Tons/year). Actually these wastes are polluting the environment.

The energetic valorization of those wastes allows the poultry breeding society to have a newable energy source (biogas) and to resolve the pollution problems.

Laboratory-scale tests have already been realized by ETAP with some universities in order to study the technology of production of biogas from the poultry waste.

4.1. Laboratory tests (fig.2)

The poultry waste is injected in the digestor (a 5 liters tight glass-containers full to the three-quarters).
During the fermentation, the biogas produced is stored in the aluminium container (6) and daily analysed in order to determin the content of CH_4, CO_2, O_2, NH_3 and H_2S.
pH.measures are performed by two pH-meters. The temperature of the substrate in the digestor is measured by a digital thermometer.
The experimentation system is formed by ten parrallel digestors.

4.2. Analysis of raw materials

For each test, the dry matter rate and the organic matter rate are determined beforehand .
The dry matter rate is determined by a dissication oven.
The organic matter rate, that indicates the pourcentage of materials wich will be decomposed, is obtained by heating a certain quantity of dry materials at 560°C during 3 hours.

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4.3. Results

The most difficult thing in mathanic fermentation is digestor start up. Laboratory work has allowed to optimise the start up technique : a large amounts of inoculum is kept inside the digestor, then small amounts of poultry waste are daily injected. The digestor will stabilise and the feeding-extraction phase will start.

The fermentation results are encouraging as shown in figure 3. As a matter of fact :

- The pH is maintained stable during the fermentation;
- The percentage of CH4 can reach 60 % of volume;
- The volume of biogas produced is about 5 l/day (capacity of the digestor 5 liters);
- And the specific gaz production rate attains about 0,40 m3 per kg of organic dry matter.

CONCLUSION

The knowledge of the national potential concerning the renewable energy is a necessary condition to warrant the development of these energies. As for geothermy and biomass are concerned, the processing researches which have been carried out revealed the existence of more or less interesting ressources and informed about the possibilities of employing these two forms of energy.

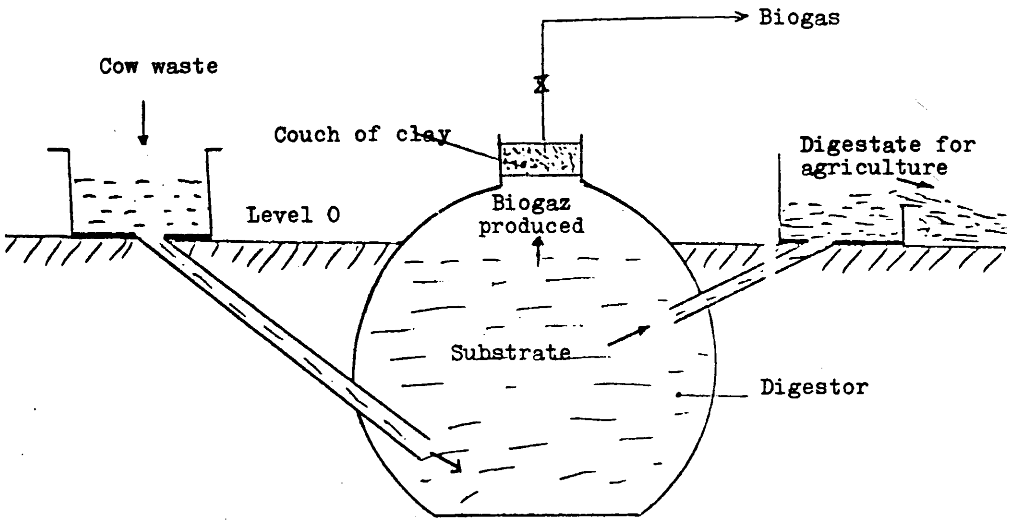

Fig.1 - The schema of digestor in Sejnane

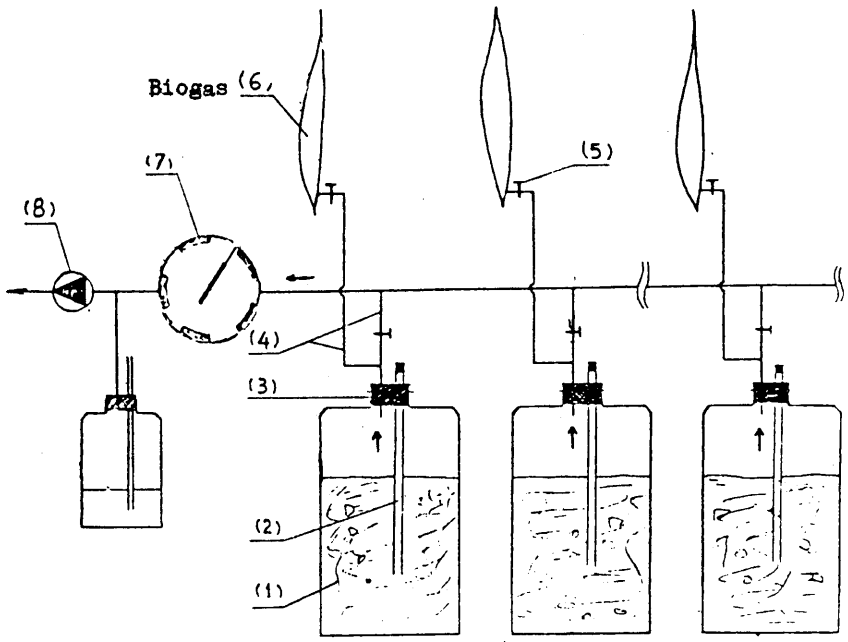

Fig.2 Laboratory digestors

1- Digestor	5- Tap in pcv
2- Tube	6- Gas pocket
3- Rubber cork	7- Gas counter
4- Gas pipe	8- Suction pump

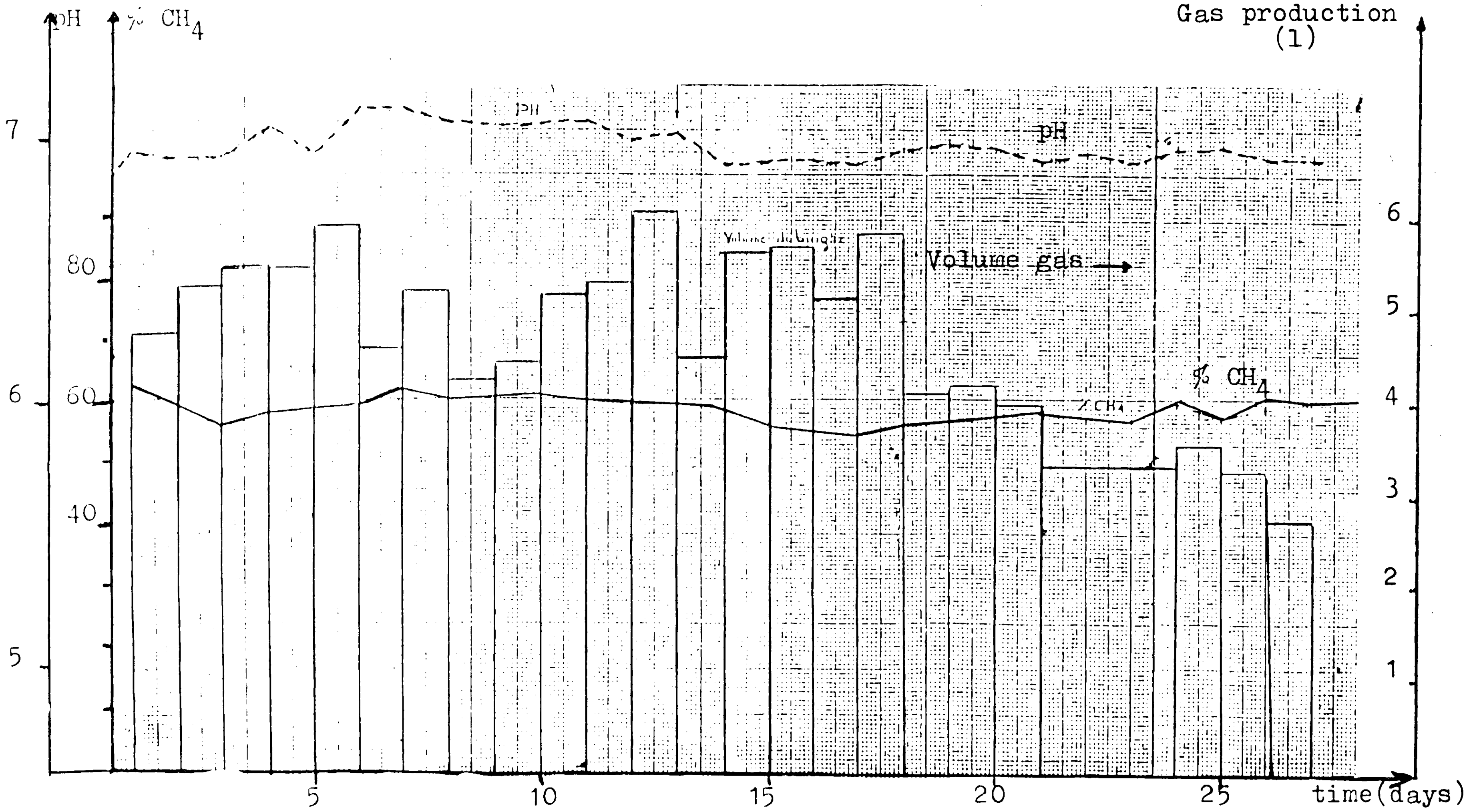

Fig. 3 - pH, methame content and gas production evolution

ANAEROBIC DIGESTION OF BIOMASS: A RENEWABLE RESOURCE OF ENERGY

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ABSTRACT

Ever increasing energy demands and limited supply of convensional fuels have generated global efforts in development of renewable sources of energy. The interest in anaerobic digestion of biomass stems from numerous benefits associated with this process. In this paper the principles of anaerobic biodegradation are discussed along with the current practices in anaerobic digester design and operation using variety of biomass inputs. The limitations of biogas plants as assessed from their operating experience in different parts of world are critically examined. Finally, the new approaches to improve and expand the potential of using biomass for energy are discussed.

1. INTRODUCTION

In the modern age of industrialization, energy is the basis for development and growth of human settlements. The energy demands are increasing progressively as global efforts are continuing to improve living standards by providing numerous mechanised fascilities for human needs. The rapid growth of population is contributing another dimension to the problem of energy crisis. The conventional sources of energy like fossil fuels and hydropower are limited not only quantitatively but also suffer from uneven geographical distribution. The non-renewable conventional energy sources are being used at such an alarming rate that the fear of their exhaustion is eminent. The cost of generation of energy by conventional sources may render them prohibitive for the poor third world countries, which in fact are badly in need of energy for their development. The advanced technology required for some of the sources like nuclear power is not available to most of the developing countries. The environmental pollution associated with the use of fossil and nuclear fuels for energy is creating another difficult problem to resolve.

1.1 Alternative Sources of Energy:

The search for alternative resources of energy is gaining impetus through out the world as energy demands are progressively

increasing. **The** renewable energy resources which involve simple technology and lower costs of generation **form** the appropriate choice. A spectrum of renewable sources of energy include wave energy, wind energy, tidal energy, geothermal energy, solar energy and biomass energy. Though the potential of some of the renewable energy resources for energy is still very marginal, **the** research and development efforts for appropriate technology of economical exploitation of these sources are in progress.

1.2 Biomass Energy:

The primary producers synthesize biomass from the carbon source and solar energy, which goes down the food chain through biochemical process of digestion. The food consists largely of biopolymers (proteins, polysaccharides, lipids and nucleic acids) and assimilation breaks them into small units. The biomass may be degraded to CO_2 and methane in anaerobic environment by bacteria. Methane gas which possesses very high fuel value is the source of biomass energy. About 90 percent of the available chemical energy in the organic material, is retained in the methane production (1). Thus, the digestion process is important in production of gas energy from the biomass. The biomass that may be utilized for gas production includes wastes from domestic and industrial premises, agricultural residues, **animal** manures and feces. The gas produced from the anaerobic biodegradation, which is 60-70 percent methane, is termed as biogas.

1.3 Advantages of Biogas Production:

The major advantages of the anaerobic digestion for biogas production are listed below:

a) It provides gaseous fuel for direct or subsequent use.

b) The effluent slurry produced has value as a land or water based source of nutrients and fertilizers.

c) It is a potential waste treatment system for human, agricultural and industrial wastes.

d) It is a relatively simple technology and one that can incorporate a high input of local resources.

2. THEORY OF ANAEROBIC PROCESS.

The anaerobic digestion of the complex organic matter (biomass) to methane is a result of the combined and coordinated metabolic activity of the digester microbial population. In simplest form it can be considered to be a three stage process. In the first stage, a group of anaerobic microorganism, primarily cellulolyte bacteria, act upon the organic polymer. The reaction is an enzyme hydrolysis of the polymer to the individual monomer. The monomers are fermented to various intermediates, mainly acetates, propionate and butrate. **Additional acetate** is produced by a second group of microorganism commonly termed as acetogenic bacteria. The acetate production is probably accompanied by coreaction of the carbondioxide reduction with hydrogen gas (2).

The acetic acid becomes the substrate for a group of strictly anaerobic methanogenic bacteria. These bacteria ferment acetic acid to methane and carbondioxide. This methane along with the methane formed by bacteria that reduce CO_2 utilizing hydrogen gas accounts for the methane production in this process. Buswell & Mueller (3) developed Eqn. 1 to predict the quantity of methane from a knowledge of chemical composition of the organic waste.

$$C_nH_aO_b + \left(n - \frac{a}{4} - \frac{b}{2}\right) H_2O \longrightarrow \left(\frac{n}{2} - \frac{a}{8} + \frac{b}{4}\right) CO_2 + \left(\frac{n}{2} + \frac{a}{8} - \frac{b}{4}\right) CH_4 \ldots\ldots (1)$$

McCarty (4) showed that the theoretical methane production from the complete stabilization from 1 Kg of BOD_L was 0.348 m^3 at STP. The methane, being insoluble in water is lost in gas phase and can be collected in gas holders. The CO_2 evolved partially escapes to gas phase, as it is relatively soluble in water. It reacts with any hydroxide ions $(OH)^-$ in the system to produce bi-carbonate ions. Consequently CO_2 evolution is function of several factor including pH, HCO_3^- concentration, temperature and substrate composition. Of the three stages the rate limiting step controls the process which depends on the type of substrate and the system temperature.

2.1 System Parameters:

The complex nature of substrate and digester ecosystem warrants their proper understanding necessary in all aspects of process design and operation. Many parameters such as anaerobiosis, temperature, pH, retention time etc. can be controlled by the design of the processing system.

A nutritionally balanced substrate, biodegradibility of substrate and absence of toxins are other factors which require special consideration for application of this system. The methogens appear to be more sensitive since the usual indication of impending process failure is the accumulation of acetates in the system. Most research todate has therefore concentrated on the response of methogens to various stumuli or inhibitary factors.

2.2 Biochemistry of the Process:

Cellulose, hemicellulose, zylane and legnin form the major part of the feed for the digestor and methane production. The enzymic breakdown of the cellulose depends on change of structure of submicro fibrils and hydrolysis to small soluble units. The bacteria are mainly involved in the polymer degradation, but fermentation ciliate flagellate protozoa and some anaerobic fungi may also be involved (2). The process does not occur readily in the presence of oxygen, sulphur, sulphates or nitrates which are alternative electron receptors. The organisms are divided into two main temperature groups. The thermophilic group is active between 40°C - 70°C and the mesophilic group from 20°C to 40°C. Methanosarcina sp. may be active at both ranges. As for pH, the optimum is about 7.0 with the range of 5-8.

2.3 History of Process Development:

The earliest microbial technologies developed some 6000 - 8000 years ago were anaerobic fermentation for production of ethanol, lactic and other fatty acids often used as preservation methods. Other processes involving anaerobic microbes were preparation of skins for tanning and retting and septic tank system for disposal of domestic waste.

Anaerobic microbes were first discovered by Pasteur during a study of butyric fermentation. He observed their ability to grow in absence of air and found that oxygen in quite small amounts was toxic to them. The first world war stimulated the study of anaerobic processes. Intensive physiological and biochemical studies on microbes were carried out in 1930s.

The first anaerobic digester was built in 1895 by Donald Cameron in the city of Exeter, U.K. The substrate was sewage solid and the methane produced was used in lighting in the vicinity of the plant. The anaerobic digestion is considered as an effective method of treating sewage sludge to stabilize it and make it suitable for utilization on farm land, as it kills many pathogens which might be present in sewage sludge. Anaerobic digestion potentially has a number of different objective, they may be required to control pollution, reduce odour nuisance or produce energy. The prime consideration of one of them would influence the digester design significantly.

Because of numerous benefits associated with anaerobic processes, it found its applications in treatment of domestic refuse and industrial pollution control. The potential of anaerobic digestion for energy generation was recognized since a long time. However, the emphasis of the research programme have been to develop practically feasible and economically viable digester for methane generation.

It is recognized that animal waste and agricultural residue are sustantial source of readily collectable biomass that could be converted into a clean useable fuel (methane) using anaerobic digestion. It is estimated that the methane generation from the organic residue can be implemented on broad scale, resulting in significant amount of biogas at competitive costs. The biogas technology also conserves valuable plant nutrients and soil humus and thus improve the crop production capacity.

3. THE DIGESTER.

The design of the anaerobic digester and the engineering associated with it depends on the type and volume of waste it is required to process together with other factors such as the geographical, environmental and social conditions applicable to the particular situation. Consequently, the digester vary widely with regards to complexity and layout. No single design can ever be considered ideal for universal application. On the basis of digestion principles the various digester construction may be grouped in six categories:

(a) Batch Digester
(b) Continuelly fed digester

(c) Plug flow digester
(d) High rate digester
(e) Anaerobic contact process
(f) Multistage digester

The digesters used for biogas production in rural location should be simple and **robust**. The main factors considered in their design concept are simple construction, ease of operation and reliability. Rural digesters are operated either batch wise or in semi-continuous way. The industrial digesters are mostly completely mixed type, operated in continuous or semicontinuous mode. The newly conceived digesters like anaerobic contact process and multi-stage digesters are designed on the basis of recent findings in the biochemistry and microbiology of methanogenesis.

4. FACTORS AFFECTING THE GAS PRODUCTION.

The biogas production in the anaerobic process depends on the substrate characteristics and the digester operating conditions. The details of these parameters are discussed in the following sections.

4.1 Substrate Composition:

Organic materials such as fats, carbohydrates and protein are main source of food for the bacteria involved in the digestion and if the amount of these constituents in the feed is known then an estimate of the potential gas production can be made. This ,ofcourse, assumes that no inhibitory substances are present and the digestion can proceed over a long period of time. As these conditions are not obtainable, possible gas production will be some what reduced. The materials for anaerobic digestion contain wide variety of organic compounds from animal wastes or **vegetable** matter. All the volatile material in the feed is not biodegradable in the period usually allowed for digestion. Pfeffer and Quindry (5) reported that for manure under mesophilic conditions, only between 30.1 and 48.2 percent of the volatile matter could actually be degraded.

4.1.1 Carbon:Nitrogen ratio:

Microbial populations involved in anaerobic digestion require sufficient nutrients to grow and multiply. If there is too little nitrogen present the bacteria will be unable to produce enzymes which are needed to utilize carbon. If there is too much nitrogen, particularly in form of ammonia, it can inhibit the growth of bacteria. It is often suggested that the optimum ratio of carbon:Nitrogen is between 20:1 and 30:1 although it is reported that for one series of experiments there was a minimum C:N ratio of 16:1 and increasing the nitrogen content did not improve digestion (6).

4.1.2 Inhibiting matter:

Methanogenic bacteria appear to be very sensitive to certain materials and environmental conditions. Being obligate anaerobes a small amount of oxygen or oxidized products such as nitrate are

inhibitory to these bacteria. It is essential that a highly reduced environment be maintained to promote the growth of these microbes. Dirasian et al (7) found that optimum digestion occured with oxidation-reduction potential (ORP) between -520 and -530 mV. Some alkali and alkaline earth-metal salts above certain concentration exhibit toxicity. Ammonia is inhibitory when present in high concentrations. At concentrations between 1500 and 3000 mg/l and pH greater than 7.4, NH_3 can become inhibitory. At concentrations above 3000 mg/l, the ammonium ion itself becomes inhibitary regardless of pH. Other common forms of toxicity include those of sulphide, heavy metals and toxic organic materials.

4.1.3 Synergistic effect:

It is reported that there was an improvement in gas production from a particular waste if it was mixed with some other waste (8). For example cattle waste on its own gives a gas yeild of 0.38 m^3/kg VS added and pig slurry gives 0.569 m^3/kg VS added. When mixed together in a ratio of 1:1, the gas yeild was 0.51 m^3/kg VS added, an increase of 7%. Similarly, a mixture of sewage and weeds in a ratio of 1:1 gave an increase of 39% over the use of a single waste.

4.2 Operating Conditions:

The operating conditions of the digester has pronounced effect on the performance and gas yeilds of the plant. The effects of temperature, pH loading rates and retention time is discussed in the following sections.

4.2.1 Temperature:

Anaerobic digestion can be carried out satisfactorily at mesophilic (20 °C - 40°C) and at thermophilic temperatures (40°C - 60 °C). Digestion under mesophilic conditions as a rule is conducted at a temperature in the range 31°C - 35°C, for maximum stabilization of the wastes. However, the optimum temperature may be significantly different for energy recovery from the digestion process.

Fair and Moore (9) found that little could be gained by raising temperature of the digester above 25°C. The results of various investigations show that the relative gas production of 0.8 - 0.9 at lower operating temperatures (20°C - 25°C) with considerable saving in energy input to the system, specially at low retention times (10).

4.2.2 pH:

Methanogens are sensitive to the pH of the digester liquor. McCarty reports that methane production proceeds very well as long as the pH is maintained between 6.6 and 7.6 (4). The optimum pH range appears to be between 7.0 and 7.2. When pH drops below 6.6 significant inhibition of methanogenic bacteria occurs. At pH of 6.2, the acid conditions exhibit acute toxicity to these bacteria. It is interesting to note that fermentative bacteria

continue to produce acids until pH drops to 4.5. When this happens, the digester is said to be 'stuck' or 'pickled'. Control should be exercised when the pH appear to drop below value 6.6 by adding alkali.

4.2.3 Retention time:

The optimum retention time can be considered to be minimum hydraulic period that can be tolerated before instability of the digester occur. For energy generation as the main objective, the situation is more complicated. Preliminary tests must be undertaken on the particular waste at various retention time to obtain a loading rate versus gas yield relationship. A study carried out in Korea (8) investigated the optimum retention times for optimum gas production for different temperatures with chicken manure and cattle manure fed to 20 laboratory digesters. Results of this study are summarized in Table 1.

Table 1 - Optimum retention time and gas production at different temperatures.

Feed	Operating temp. (°C)	Optimum retention time (days)	Gas production (L/L-d)	VS destroyed (%)
Chicken manure	15	55	0.48	50.8
	25	30	1.38	61.1
	35	20	1.45	75.0
Cattle manure	15	60	0.24	40.0
	25	35	0.48	60.0
	35	30	0.66	65.0

This shows that the optimum retention time falls rapidly for lower temperatures and higher gas yields are observed at higher temperatures.

5. CURRENT BIOGAS TECHNOLOGY.

The biogas technology is finding increasing use for energy generation around the world. The large scale plants are based commonly on the use of industrial wastes and sewage sludge. The medium and small sized biogas plants used on farm scale and family scale are more popular with the rural population. The farm scale plants using animal manure and agricultural residue are being increasingly used in less developed countries.

The economic feasibility of biogas technology is quite complex as the process may have multiple objectives, which are difficult to be assessed in monitary value. It is symptomatic that the process of anaerobic digestion is almost identified with its gaseous output - rather then viewed as a technology contributing towards a number of objectives viz. energy supply, nutrient and organic recycling, waste treatment and development based on local resources and skills. The small scale plants if assessed only on energy supply basis are not economically attractive. However, research efforts are aiming to improve the economic viability of

biogas plants on all scales.

Most of the interest in biogas technology comes from the third world countries of Asia and Pacific region. The work on biogas in Africa and Latin America has made little real impact on its development. Specific mention of the developments and utilization of biogas technology from some of these countries would not be out of place.

5.1 China:

China has produced a record of success stories on utilization of biogas technology. About half a million family size biogas plants of around 10 m^3 capacity and capable of producing 5 m^3 gas per day are in operation in China. A standard construction procedure is used for biogas plants, which have no moving parts. The construction is done according to local conditions in bricks cement and stones, and the gas pressure is regulated by water levels. The feed is mostly composed of night soil, urine, vegetable matter and water. The pH is controlled to around 7.8 by adding lime. The detailed account of the chinese biogas technology may be found some-where else (11).

5.2 India:

A number of biogas plant designs are developed in India, but most of the biogas plants in India are based on KVIC design. The plant size ranges from 1.5 m^3 to 140 m^3. The smaller domestic units are unheated and unstirred with retention period of around 55 days. The metal gas holder form the major portion of cost of biogas plant in KVIC design. Most of the plants are working on cow dung as the input and lack in integrated approach to the biogas technology. The biogas has met with variable success in India due to various technical, organizational and economical reasons. (12)

5.3 Korea:

It is reported that about 29,000 small plants have been installed in Korea. However because of the low winter temperature, the plants were effective only for six to seven months of the year and the attempt of mass scale use of biogas could not gain impetus. The trials and developments are continuing to over-come the basic problems. (13)

5.4 Philippines:

The use of agricultural residues has been identified as of significance in the Philippines for integrated recycling systems. One installation of special interest is Maya farm plant, which is the largest plant handling effluent from 7500 pigs (12). The gas is used for cooking and powering engines and the liquor is used for fertilizer and algal feed. The plant consists of 48 X 3 m^3 batch digesters as against continuous digesters commonly conceived at this size of feed.

5.5 New Zealand:

A concept of 'energy farming' on the basis of biogas technology is launched in New Zealand. Special energy crops are being investigated for their economic feasibility for biogas production. It is estimated that biogas may contribute a significant share of national energy requirements and may supplement the convensional fuels (14).

6. TECHNICAL ASPECTS OF BIOGAS TECHNOLOGY.

The performance of a biogas digester depend on number of interrelated parameters. The field experience obtained through operating plants provides guidelines on optimal design and operations of biogas plants. Some of the important technical aspects of biogas technology are discussed in the following sections.

6.1 Composition of Plant Input:

It is observed that the quantity of gas produced depends on the type of feed. Cow dung, which is a common feed for Indian digesters shows poor digestion in comparison with the other manures. Table 2 presents the biogas production for different types of wastes.

Table 2 - Production rate of Biogas for different wastes.

Type of waste	Production rate m^3/kg of dry matter
Chicken manure	0.35 - 0.80
Cow manure	0.20 - 0.30
Pig manure	0.36 - 0.48
Sewage sludge	0.35 - 0.50
Straw, grass	0.35 - 0.40
Green vegitable waste	0.35 - 0.40

Mixing different types of wastes to make the digester feed improves the performance biogas plant. The wastes with higher nitrogen content increase the biogas production. A C:N ratio of 1:30 is common in Chinese practice.

6.2 Frequency of feeding:

Continuous feeding is not practical for farm scale digesters. The digester is mostly fed once daily in Chinese technology while in India the practice is to feed digester 2 to 3 times a day. It is observed that the performance of digester would improve with higher frequency of feeding.

6.3 Organic Loading:

The organic loading rates, defined as kg of volatile solids fed per unit volume of digester per day, depends on the temperature

of the digesting liquid in the plant. Maximum organic loading for mesophilic range may be 2.3 kg of VS/m^3-d and that for thermophilic range is 5-6 kg VS/m^3-d. For Indian digesters the organic loading rates ranges from 1.6 - 2.0 kg VS/m^3-d. Higher loading rates may be permitted for higher solids content in the feed.

6.4 Dilution and Retention Time:

The dilution of the feed manure is essential for control of solids and to make the feed workable. The retention time is directly related to the quality of feed. Though longer retention periods bring about better stabilization of organics, the gas yields do not show significant improvement after a certain period. A dilution of 1:1 is commonly practiced in India while Malaysian plant use 1:4 dilution. The retention time ranges from 30 - 50 days in most of the biogas plants.

The digested slurry forms a good fertilizer as it contains about 3.5% nitrogen. The digester solids contain organics as high as 74% which may be used as a good soil conditioner.

7. CONCLUSIONS.

The biogas technology has passed through phases of development and testing, and has proved its worth for energy specially in rural locations and less developed countries. Perhaps, in recognizing the crucial role of biogas technology, it remains to be seen whether the objectives of easing the commercial energy problems by using local renewable resources and provision of energy to the rural population can be solved simultaneously.

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THE VALUE OF LEAD-210 RESEARCH IN GLOBAL BIOGEOCHEMICAL CYCLES

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ABSTRACT

Radon-222, emanating from lands, decays to lead-210 which after a short residence in the atmosphere, a week or so, is introduced either directly or indirectly to various aquatic systems (rivers, soils, peatlands, lakes, oceans, polar and glacial ice. In addition to this atmospheric "unsupported" lead-210 other local contributions due to radium-226 may occur which could be either unsupported or "supported" lead-210. For ombrotrophic peats, polar- and glacial-ice the supported lead-210 is extremely little.

The unique "global cycle" of lead-210 (Fig.1) allows most atmospheric and aquatic species to undergo analogous biogeochemical pathways before being deposited and preserved in permanent sinks. Beside its chemical identity as a heavy metal the lead-210 is a radioactive nuclide with about 22.3 y half-life time. These properties make lead-210 not only a good dating tool for deposits up to 150 y but also a suitable atmospheric and aquatic tracer of environmental and ecological components.

The utilization of the Global Biogeochemical Cycle of Lead-210 in earth and environmental sciences would be discussed. Monitoring the history of atmospheric pollution such as environmental radioactivity, heavy metals, acid-oxides as well as eutrophication of fresh- and salt -water bodies would be commented.

(NOTATION: 1 Ci = 37 GBq)

1. INTRODUCTION

Although energy resources of our planet existed long before the first simple forms of life on the Earth it took extremely long time to allow for the evolution and stability of the present-day complex -structure of the Earth's ecological systems. The survival of man necessitates CONTROLLED CONSUMPTION OF NATURAL ENERGY RESOURCES AND CONTINUING STABILITY OF GLOBAL ECOLOGICAL ENVIRONMENTS. The increasing population and the accelerated participation of man in modern energy-demanding techniques have created obvious perturbations and damages of our environments specially during the past century. Environmental monitoring is thus an important step in evaluating the quality of present and past environments and represents a bases for environmental protection policies. Among the most important environmental changes of recent character are pollution of the atomsphere and hydrosphere by anthro-pogenic heavy metals, acid-oxides, chemical and radioactive waste as well as eutrophication of aquatic systems especially lacustrine and marine ones. Modelling the history of such changes on global and local scales requires routine monitoring of current levels of ecologically reactive substances and careful analyses of past environmental changes as witnessed in natural deposits .

Routine monitoring of present-day environments serves as an early warning for: (1) catastrophic events such as failure of power-stations, nuclear and chemical industries; (2) shifts in principle quantities and parameters controlling primary production, stabilities and qualities in nature including levels of nutrients and pollutants. Historical monitoring, on the other hand, provides important information on past environmental changes, causes and levels on global and local scales. Thus a complementary data-bank of present-day records could be done by reconstructing the preserved chronological-records of undisturbed deposits especially lacustrine-, marine-sediments, peats and polar-ice [1] as well as fresh-water mussels [2] and deep-sea corals [3].

Accurate modelling of the past environments would depend on careful selection and sampling of deposits, temporal and spatial resolutions of records obtained as well as their statistical validities. In historical monitoring almost all kind of natural deposits have been utilized, with varying degrees of success, to give reliable temporal-records of regional and global changes. A key parameter in utilizing natural deposits in historical monitoring and environmental modelling is VALID CHRONOLOGICAL TIME-SCALES IN CALENDAR YEARS. The LEAD-210 METHOD has proved to be an essential dating method for constructing time-scales up to 150 y and a valuable tool in modelling recent atmospheric, aquatic and depositional processes [4-7]. However, the credibility of lead-210 chronologies could be enhanced by suitable combinations with other tools [7-8]. In integrated investigations such as mass-balance studies of lakes many cores representing the whole water-body are used and the construction of a whole-lake chronology would involve core-correlations [9]. Mass-balance studies are of extreme importance in evaluating multi-system interactions [10] and related global changes [11].

In assessing palaeo-environmental changes it is quite obvious that one has to differentiate between atmospheric and non-atmospheric inputs of various components. Nevertheless, this is a challenging and difficult aspect in environmental research. Polar-ice, mosses and ombrotrophic "rain-fed" peats, if well selected and treated, would presumably mirror atmospheric records [1]. Lakes and coastal marine environments, in addition to their atmospheric inputs, receive other contributions from adjoining compartments because of transported materials from lands as in lakes [12] and/or off-shore waters as in coastal marine areas [13]. Soils could also be used to monitor total inventories of some atmospheric air-borne materials such as radioactivity and heavy metals [14], however complications from background contributions may exist. Generally speaking well-selected deposits with valuable atmospheric data should satisfy the following criteria [15]: (1) Records under investigation ought to be of atmospheric origin. In cases where additional inputs occur corrections should be carried out; (2) The biogeochemical and depositional conditions of the depository system should allow quick "contemporaneous" and complete accumulation "quantitative" of components to be modelled; (3) Post-depositional processes which may disturb the original order of accumulated materials should be either absent or well examined so as proper normalization could be done; (4) Deposits should yield reliable and continuous chronologies with

good resolutions. As these criteria are not likely to be fulfilled for all records desired it would be neccessary to combine and extend records obtained. Knowledge of palaeo-atmospheric fluxes would certainly facilitate modelling of non-atmospheric species.

2. THE GLOBAL LEAD-210 CYCLE AND TRACING APPLICATIONS

The utilization of lead-210 in chronological studies of recent deposits was introduced by Goldberg [16]. Since that time this radioactive nuclide was applied to lacustrine [17-31]; riverine [32-33]; estuarine [29,34-37]; coastal marine [13,26,38-44]; soils [14,45-48]; ombrotrophic peats [15,49-55]; polar- and glacial-ice [16,56-62]; as well as atmospheric [5,63-68]; surface-water including the mixed-layer of the ocean [32,34,69-73] and oceanic studies [13,74-77]. These studies provided valuable understanding on essential processes controlling the global cycle of lead -210 and demonstrated various important applications .

Figure (1) shows a summary on various sources, pathways and sinks of lead-210 in the globe. Almost all atmospheric lead-210, "extra" or "unsupported" lead-210, (half-life time = 22.26 ± 0.22 y) is produced from land-injected radon-222 (half-life time = 3.8 d). Land-areas with productive radon-222 emanation are characterized by having high intrinsic radium-226 concentrations, free from glaciers and permafrost. Meteorological conditions are the major parameters controlling radon-222 exhalation from lands [78]. About 3% of the land-emanating radon-222 is introduced from world oceans and other terrestrial sources. Radon-222 is removed from the atmosphere by its radioactive decay to a series of short-lived radioactive nuclides with half -lives up to about 27 min : polonium-218, lead-214, bismuth-214, polonium-214. These radioactive nuclides are very particle reactive and they become attached to atmospheric aerosols immediately after their creation. The decay product lead-210 as well as other reactive chemical and radioactive species are removed by further aerosol scavenging and atmospheric precipitation processes. The lead-210 residence time in the atmosphere, a week or so, is long enough to allow

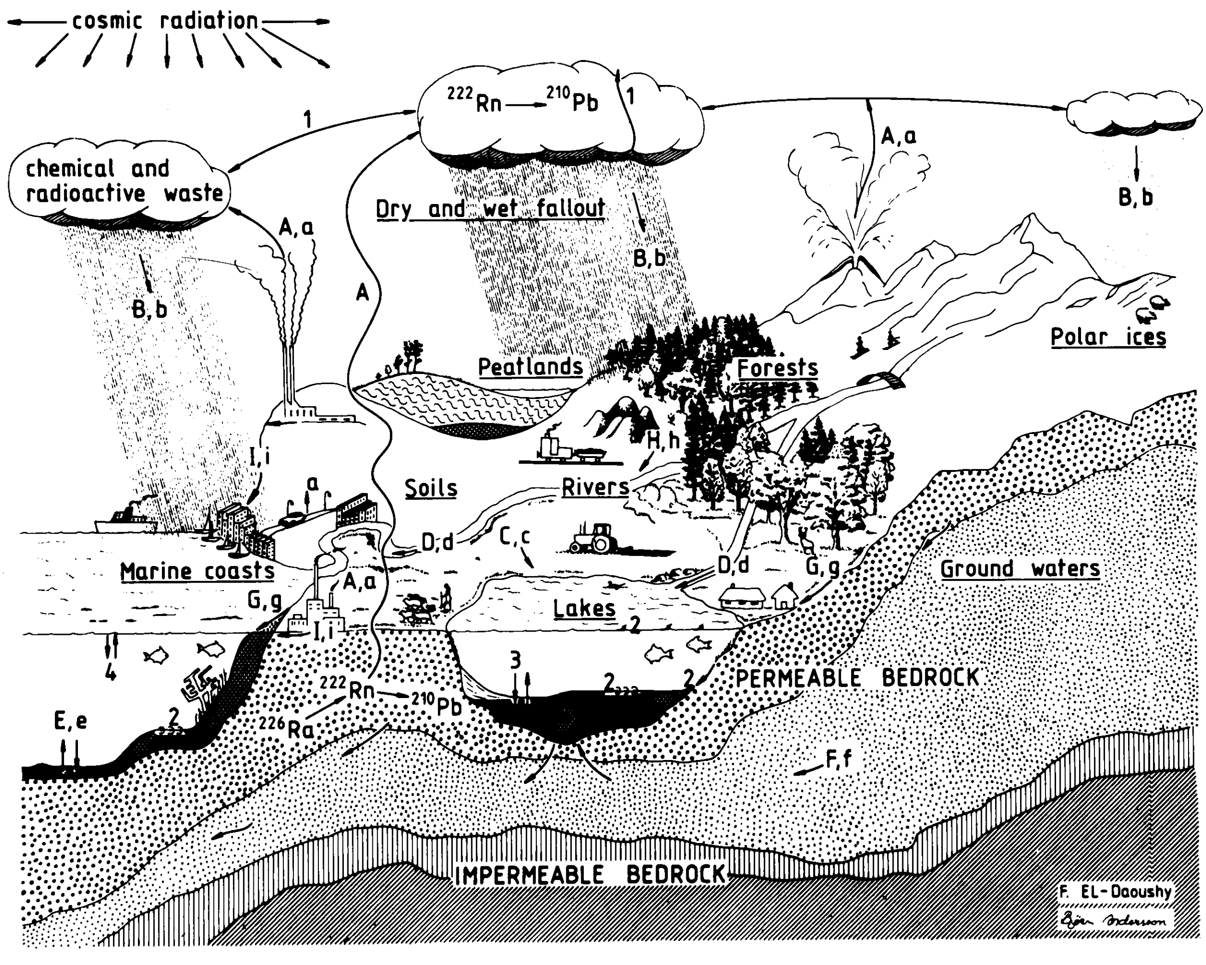

Fig. (1) The lead-210 global cycle and related applications in earth and environmental sciences. The major part of land-exhalated radon-222 is quickly transformed to lead-210 which is regionally mixed with other volcanic and artificial remains ejected "A,a" as well as cosmogenic nuclides produced. Capital letters mean possible sources and pathways of lead-210 while small letters denote analogous environmental remains following lead-210 to "permanent" sinks. "A" may also represent airborne non-cosmogenic radioactive nuclides of natural or artificial origin which could be investigated or correlated with lead-210. "a" means chemical waste from power stations, vehicles, chemical industries and volcanic activities. After being transported and mixed by various atmospheric processes (1) the materials A,a are brought to different aquatic and ice reservoirs by dry and wet fallout "B,b". B and b patterns are dependent on meteorological conditions. The biogeochemical interactions of surface waters with soils, farming and mining lands modify the water quality before reaching ground-waters, rivers, parts of peatlands, lakes and marine coasts. Mining (H,h), farming (C,c) and other land-use waste may reach rivers and lakes via drainage areas. River (D,d), groundwater (F,f) and land-eroded materials (G,g) with different nutrients (phosphorus and nitrogen) and pollutants are discharged to lakes and marine coasts. These systems may receive direct remains (I,i) from power plants (fossil-fuel and nuclear), industrial and urban activities. The physical, chemical and biological remains are then deposited, mixed/ mobilized by various processes such as: lateral transport, bioturbation and/or resuspension (2); pH- and red./ox. -induced reactions (3) as well as diffusion (E,e), and finally ACCUMULATED AND PRESERVED.

Lakes and marine sediments have been widely used as general environmental indicators. Undisturbed sediments with reliable chronological records are usually found at "accumulation bottoms". Polar and glacial ices as well as ombrotrophic peats, although their limited utilization, proved to give complementary and valuable global data as they exist in regions where sediments may be of minor importance. Peats could be found in all continents and in combination with soils additional global information on integrated atmospheric fluxes could be obtained. For short-term records of local and regional anthropogenic pollution air-filters, mosses and lichens, tree-rings as well as mussels and corals seem to give detailed information specially if analyzed by modern chemical and physical techniques.

for tropospheric circulation [68] and mixing with other chemical and radioactive species with similar atmospheric behaviour. Almost all atmospheric reactive elements/compounds, including lead-210, are brought to the earth by meso-scale transportation processes [79] as well as dry and wet precipitation [67]. It must be kept in mind that the atmospheric patterns of lead-210, radioactive nuclides and chemical waste are entirely different and depend primarily on production sources. Generally speaking atmospheric lead-210 concentration levels are related to the size of radon-producing land-masses. High values of lead-210 concentration in surface air could therefore be found at mid-latitudes with rapid decreasing gradients towards high-latitudes [66] . Unlike lead-210, the atmospheric distribution of particle reactive radio-isotopes such as tritium, silicon-32, beryllium-10 and strontium-90 as well as nobel gases and carbon-14 are dominated by their stratospheric injection pattern [5]. It is quite obvious that even under constant radon-222 production the atmospheric lead-210 concentrations would experience a great daily and seasonal variations because of different aerosol intensities, properties and prevailing meteorological parameters. Although the particulate form of lead-210 the seasonal variations of lead-210 and radon-222 in the atmosphere are somewhat similar [63]. This would imply that atmospheric lead -210 fluxes could be described in terms of radon-222 concentrations in the atmosphere.

The deposition of lead-210 to the earth's surface would be controlled by dry and wet precipitation and its annual precipitation fluxes would be enhanced by the frequency and rate of rainfall [80]. Considering an average prodution rate of radon-222 from productive continental lands to be about 42 atoms/sq.cm/min [81] atmospheric lead-210 fluxes of $\leq$ 0.6 pCi/sq.cm/y could be calculated for such areas. However, as about two-third of the earth's surface produces negligible amounts of radon-222 a global annual lead-210 deposition-rate could be estimated to $\leq$ 0.2 pCi/sq.cm. Although the significant geographical variations of lead-210 deposition rates, annual variations are relatively limited and standard deviations of about 30% could be obtained for mean-values of five-year periods [5]. The actual annual lead-210 deposition rates were found to vary from $\geq$ 0.05 - $\leq$ 0.40 pCi/sq.cm/y for Australia and New Zealand [67,82] up to $\geq$ 0.6 - $\leq$ 1.3 pCi/sq.cm/y for Japan [80]. The corresponding values for U.S.A., U.S.S.R., Great Britain/ Ireland, The Netherlands, and Scandinavia are $\geq$ 0.4 - $\leq$ 0.7 [34,47,83], $\geq$ 0.2 - $\leq$ 1.5 [84], $\geq$ 0.2

- ≤ 0.6 [6,21,54], ≥ 0.19 - ≤ 0.24 [85], and ≥ 0.1 - ≤ 0.2 [23,64] pCi/sq.cm/y respectively. These values are extracted from earlier studies of direct atmospheric measurements, soil and ombrotrophic-peat as well as some selected undisturbed lakes. Lead-210 deposition in West Germany seems to be somewhat higher than The Netherlands a value of 0.27 pCi/sq.cm/y has been calculated from a soil-core by Hemmerich [86]. Nevertheless, extremely low fluxes of lead-210 have been reported for polar regions, ≥ 0.002 - ≤ 0.05 pCi/sq.cm/y [56,57]. Statistically valid fluxes with good geographical coverage are still needed because of their great value in various tracing and dating applications.

The atmospherically deposited lead-210, chemical and radio-active materials are directly delivered to the surface mixed-layer of the oean and permanent sinks such as soils, ombrotrophic peatlands, polar and glacial ices. Atmospheric inputs in combination with various contributions from the land (physical and chemical erosion) would be rooted through hydrological cycles to rivers, lakes, estuaries and coastal marine environments [7]. As undisturbed soils and peatlands may act as effective filters minor amounts of atmospheric and land-produced materials are expected to reach groundwaters. Coastal marine regions are high productive and efficient scavenging sites [13] and therefore additional fluxes other than atmospheric and land-induced ones may be found there. Only about 25% of the lead-210 in the mixed-layer of offshore oceanic-waters reach deep waters because of poor exchange processes and stratification in the sea [71] as well as the radioactive decay of lead-210 due to its long residence-time in deep oceanic-waters, ≤ 20 to ≥ 150 yr [87-88]. As much shorter residence-times in the deep sea are quite possible [74] higher lead-210 deliveries to the sea bottom may exist.

Lead-210 and radioactive nuclides as well as heavy metals and acid-oxides are usually introduced to global environments especially atmospheric ones in simple chemical forms depending on sources of emission. Most of these atmospheric and non-atmospheric species are particle-reactive and behave in a way similar to lead-210, and their modelling would thus be possible by using lead-210 as an environmental tracer. Other "less-reactive" compounds such as fluorocarbons, combustion-carbon (aromatic hydrocarbons and soots) and volatile organic-gases have also increased dramatically in the atmosphere during the past century [89,90]. More complicated forms of environmental pollutants such as oil and refineries waste, phenols, cyanides, fluorides, synthetic organic chemicals, PCBs, DDT and soil-remaining fertilizers are chemically passive and need quite long time to be decomposed to simple chemical compounds [91]. The last mentioned pollutants are either directly injected to various fresh- and salt-aquatic systems or being transported to them by dispersion and erosion. Under favorable geochemical conditions simple and particle-reactive pollutants are subject to rapid removal and enrichment in water-bodies through adsorption (inorganic) and chelation (organic) on settling paticulate matter. However, peatlands may accumulate lead-210 through biological assimilation of leaf and/or root systems. Adsorption is a particle-size and particle-composition dependant process while chelation is more energy demanding and involves retention of metallic ions by humus remains. Thus one can assume that lead-210 and other particle-reactive species undergo further homogenization in surface waters before their final accumulation fate in depository sites. It is, however, important to mention that some part of these materials may remain soluble in the waters. The chemically passive pollutants are accumulated/deposited at varying rates, depending on their physical and chemical properties, by physical adsorption, entrapment and flocculation. Some of the last mentioned pollutants are not likely to be contemporaneously deposited with lead-210 as they may have longer residence-time in the waters. Because of the chemical stability of PCBs and DDT compounds these pollutants are considered to be highly toxic and are able to be preserved and enriched in food-chains specially milk and animal fats.

The global distribution-pattern of atmospheric lead-210 could still be seen in rain and the surface mixed-layer of the open sea although somewhat modified [66,73]. Because of the low accessibility of particulate matter in offshore surface water compared to coastal marine environments lead-210 is found in soluble form [77]. Although the availibility of radium-226 in deep sea waters the in situ lead-210, "supported" or "non-atmospheric" lead-210, suffers remarkable deficiency because of its rapid removal [76]. In these waters [74,75] as well as soils [45,48] the major part of lead-210 is supported lead-210. Ombrotrophic (rain-fed) peatlands [50],

glacial and polar ices [56.57] have negligible amounts of supported lead-210. However, elevated levels of lead-210 may occasionally be found in lakes because of high radium-226 in the water and/or eroded minerals [23,92]. The residence-time of lead-210 is shortest in streams and rivers (days to weeks) specially if its accumulation is accelerated by iron and manganese precipitation [70]. Assuming reasonably long water-turnover time, complete accumulation of lead-210 would require up to some month in estuaries, small lakes and marine coasts. Lead-210 may need up to some years to reach bottoms of large lakes [92]. Few years (1-2) seems to be a realistic residence-time of lead-210 in old aquifer and offshore surface sea-water. Very long residence-times have been reported for deep sea-waters ≤ 20 to ≥ 150 y , nevertheless shorter times have been observed as well [74].

It is quite clear from the previous description that lead-210 could be used for historical monitoring of atmospheric and aquatic waste with different degrees of success depending on chemical reactivity and residence times of environmental waste. However, the selection and collection of undisturbed and preserved deposits "closed systems" as well as the construction of valid time-scales in calendar years are essential steps to obtain reliable chronological data on global biogeochemical cycles.

3. LEAD-210 DATING PARAMETERS AND MODELS

As ideal conditions of closed systems are very difficult to be found in nature it is quite important to understand and evaluate the conditions under which chronological anomalies arise and to develop necessary solutions and corrections for them. For a given depository system the accumulated original sequences should be protected against external and internal processes which may disturb the chronological order of the system or parts therein. Unlike soils, riverine, lacustrine and marine systems,the ombrotrophic peatlands, polar- and glacial-ice suffer mainly from internal deforming/disturbing processes. Internal and external processes influencing modern depositional sequences and related dating approaches are discussed in detail elsewhere [4,6-8,27,30,39,44,50,54,93-94].

As lead-210 dating is based on the unsupported lead-210 (atmospheric origin) in deposits it is obvious that the supported lead-210 (in situ) must be carefully estimated [23]. This is usually done by measuring: 1) lead-210 in samples older than 150 y; 2) radium-226 of depository sequences; 3) lead-210 of the 1% HCl and 0.5% NaOH insoluble fraction [7]. Unfortunately non of these could serve as a standard approach for the determination of environ-mental supported lead-210 levels. The first approach proved to be applicable in most cases of fresh-water lakes except disturbed ones which may show unreliable levels and therefore the remaining approaches must be utilized. In marine studies comparison between radium-226 and lead-210 are of special importance as: 1) these radionuclides may suffer obvious disequilib-rium or; 2) be in equilibrium but showing a varying level of supported lead-210 with depth. In both cases these anomalies may extend to samples older than 150 y, however the third approach would be of valuable help.

In totally or partially closed systems, the lead-210 age calculations are based on the assumption that the unsupported lead-210 fluxes delivered to, and maintained by, a depositional sequence should be constant during the past two centuries or so; this is known as the Constant Rate of Supply model, C.R.S.. In cases where sedimentation rates have been constant in time the initial unsupported lead-210 concentrations would be also constant, and the model used to deliver ages is called the Constant Initial Concentration model, C.I.C.. According to these models [4,6] the age of a certain layer in a given depositional sequence would depend on either the remained lead-210 activity beneath this level relative to the integrated lead-210 activity of the sequence (C.R.S. model) or the lead-210 concentration of the level in question compared to the top surface-layer (C.I.C. model) :

$$A = A_0 \exp - \lambda t \qquad \underline{\text{AND / OR}} \qquad C = C_0 \exp - \lambda t \qquad (1)$$

where A_0 and C_0 are the integrated unsupported lead-210 activity (pCi sq.cm) and the initial specific lead-210 activity (pCi/g) of the sequence respectively, C is the lead-210 concentration in a certain layer of age t (C.I.C.) beneath which the integrated lead-210 activity is A. The

sedimentation rates w could be obtained by deviding the depth increments with corresponding ages. In order to avoid problems arising from compaction depths could be replaced by masses using density and porosity values of the corresponding layers. In both the C.R.S. and C.I.C. models the lead-210 flux could be given as:

$$\Phi = \lambda A_0 = \lambda \sum_{m=0}^{m=\infty} C(m)\, dm \qquad (2)$$

where Φ is the annual unsupported flux (pCi/sq.cm/y) at a certain site, λ is the decay constant of lead-210 ($\lambda = \ln 2/ T(½)$), and A_0 is the cumulative unsupported lead-210 of the depositional sequence from mass zero at the surface to mass ∞ at which supported lead-210 exists only, C(m) is the lead-210 concentration in a layer of mass dm. As annual lead-210 fluxes (or inventories) may not be uniform at all depositional sites it would be necessary to devide aquatic systems to several compartments representing the actual lead-210 pattern in the system under consideration. This approach could also be utilized to study the influence of various internal and external processes on the accumulation of lead-210 and associated chemical analogues in local and global environments (lakes, marine coasts, soils and peatlands or the like). For a given system the average lead-210 flux could be described as follows:

$$\overline{\Phi} = (\lambda/S) \sum_{x=\ell}^{x=m} (A_0)_x\, a_x \qquad (3)$$

where $(A_0)_x\, a_x$ is unsupported lead-210 inventory in an area defined by the zone parameter x in a system with a total surface area S and active depositional zone-boundaries l and m. These calculations are of prime importance in modelling the efficiency of environmental systems to accumulate and hold different pollutants/nutrients as well as multi-system interactions. An interesting application is the infiltration of environmental pollutants to groundwaters due to acidification-induced solubilization.

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UTILIZATION OF LIBYAN DESERT DEPRESSIONS FOR POWER GENERATION

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ABSTRACT:

In recent years there has been a growing interest in the physical characteristics of desert basins, particularly playas, for various practical purposes. Features of significance include nature and properties of materials at and below ground level, configuration and microrelief of the surface, and hydrological conditions. A great deal of study has been devoted to playa phenomena, and much has been learned about the factors which relate to them, although much still remains to be done.

The objective of this paper is to study the possibility of utilizing some of the Libyan Desert depressions for power generation by admitting sea-water into them with a considerable fall from the Mediterranean sea, the influx being continuously disposed of by evaporation from the surface of the salt lake which would thus be formed within the depression. The proposed project include extending canals and or tunnels conecting the Mediterranean sea to the selected depressions. The various aspects of the recommended project and the different factors effecting it are also discussed.

INTRODUCTION:

The topography of the Libyan Desert is characterized by more or a less central groups of discontinous mountains and uplands, surrounded on all sides by areas of lower relief. The terrain in general away from the dominant mountains, is characterized by broad plains and basins, variously interrupted or separated by irregular hills, plateaus, and low mountains; abrupt escarpments are common. Some of the basins if carefully studied may be utilized for various useful projects. A more reasonable prospect seemed to be that of admitting sea-water from Mediterranean into some selected basins by means of a canal or a pipe. Some of the advantages which might occure from the formation of this inland sea are an increase in the

humidity of the climate along the Mediterranean sea and along the route of the canal, leading to increased rain-crops in that region, the establishment of a valuable fishery and possible increase in the water - supply of the oases by causing of a slight rise in the static water level there.

Another idea is to utilize some selected depressions as a source of electrical power for driving pumps by which the drainage of the region might be improved. The salt marshes which cover much of the floor of the depressions appeared suggestive of a former Sea - connection, and if we could trace out this old connection, the cutting of a canal along it might not be very expensive matter. Moreover, it is apparent that evaporation from an inland sea or lake of so large an area would keep pace with quite a large influx from the Mediterranean, so that if the influx were restricted to such a quantity as would of the lake - surface being maintained at a level considerably below that of the Mediterranean, power could be generated continously.

ORIGIN OF THE DEPRESSIONS:

A possible cause of the depressions is to be found in earth - movements either a local down-folding of the crust, or an upraising by faulting of the surrounding tracts. It is not unlikely that such earth - movements have to some extent conditioned the formation of the depressions; but that the depressions are not simply faulted down areas or subsidences is abundantly clear from an examination of the bounding scraps and the floors of the larger oases. It is, in fact, obvious that these great hollows are natural excavations,not subsidences. We can thus possibly invoke water-action to account for the primitive formation of the depressions. There is no doubt that wind has been the main excavating agency. All the depressions occur in areas where soft rocks are overlain by hard ones, and once the hard overlying rock was removed at any place, the action of wind on the softer beds would soon excavate a hollow.

THE DEPRESSION

Since no complete data is available on most of the depressions in the Libyan Desert, only one site Sabkhat Al-Quonayyin was considered in this paper. The depression has an area of 2100 square Kilometers and approaches within 77 kilometers of Ajdabiya city and 100 kilometers of the Mediterranean Coast (Table 1). The lowest point of the floor of the depression is about 40 meters below sea-level and a large proportion of the floor is covered by Sabkha, which is a mixture of sand and salt, generally with more or less water. In some tracts the sabkha directly overlays solid ground presenting a rough ridgy surface which can be travelled over, though with difficulty, in dry seasons; but over large areas it forms merely a solid or semi-solid crust overlaying salty sludge, and is therefore quite impassable.The remainder of the depression floor is mostly formed by sands, gravels, clays, and limestones.

Sabkhat (Depression)	Approximate Area (Km2)	Approximate Distance from Sea Coast (Km)	Approximate Depth below Sea (m)
Al Kabirah	1200	35	?
Al Quonayyin	2100	100	40
Talib.	126	On the Coast	?
As Sham Ash Shuwayrib	208	2	15
Tawargha Al Hisha	2190	On the Coast	?
Umm Al-Izam Al Hamra	72	90	?
Maradah	784	105	?

? = No data available

Table 1.

AMOUNTS OF POWER TO BE GENERATED:

Since a Kilowatt is equivalent to 102 Kilogramme-metre per second, the gross rate of evolution of energy from Q cubic metres per second of sea-water of density 1.025 falling through a height of H metres will be 1025 QH/102; and taking the value of Q (permissible influx) as 656 cubic metres per second, this gives 263,000 Kilowatt for the gross rate of evolution of energy with lake at 40 metres below sea. Of this total energy however a considerable proportion would be lost in the conduits and in the generating plant. The amount of lost energy is somewhere about 40 per cent, leaving only some 60 per cent or so of the gross energy for available output. The developable net output at the generating station would thus be roughly about 160,000 Kilowatts.

PROPOSED PROJECT:

It is easy to note that a single tunnel to convey the whole permissible influx to the lake would have to be of exceedingly large diameter. In our case (40 metre lake), for instance, even if we were prepared to sacrifice as much as three eighths of the total fall in giving slope to the conduits and a circular tunnel to pass 656 cubic meters per second with this degree of slope would need to be at least 17.3 metres in diameter. So large a tunnel as this would probably be quite impracticable; even if it were practicable, it would be very expensive to construct; and it would present the three further serious disadvantages that the whole outlay involved in its construction would have to be expended before

there could be any return on the capital, the power available from it would most probably be considerably in excess of the immediate demand, and periodical inspection of its interior would not be possible without temporary suspension of the entire output. The division of the influx between at least two tunnels thus appears to be imperative; and three tunnels would probably be better still, as not only bringing the necessary diameters down to within practicable limits, but also diminishing the initial capital outlay (since only one of the three tunnels need at first to be constructed, and would probably suffice for initial power requirements), and eventually permitting of inspection of the interior of the tunnels being carried out without the temporary suspension of more than one-third of the total power output.

RECOMMENDATION FOR FURTHER RESEARCH:

A further research should be carried out to explore the following points:

- A study of the evaporation, inward seepage to the lake, outward seepage from the lake, rainfall and time required to form the lake and salting-up of the lake.
- Economic study including the total cost of the project and the expected revenue.
- A complete detailed mapping of the depressions at a large scale showing the contour lines should be completed to know the exact depths and extents of each depression.

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وضع الطاقة في لبنان و دور الطاقات الجديدة و المتجددة

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مركز بحوث الطاقة الشمسية ــ المجلس الوطني للبحوث العلمية
(بيروت ــ لبنان ــ ص•ب• ٨٢٨١ ــ ١١)

ملخص :

لبنان بلد مستهلك للطاقة نظرا لفقدان المصادر الاساسية لها كالبترول و الفحم و ما شابه ذلك ، ما عدا بعض المصادر الهيدرولية لانتاج الطاقة الكهربائية•
تقوم بعض الادارات و الجمعيات و المؤسسات العلمية الخاصة منها و العامة بدراسات حول وضع الطاقة (مصادرها ، استهلاكها) في لبنان • تبيّن لنا من هذه الدراسات ان لبنان يستورد اكثر من ٩٠٪ من احتياجاته للطاقة من المشتقات النفطية• اما الجزء المتبقي فينتج محليا بواسطة محطات هيدرولية موزعة على انهر لبنان • و بلغت القدرة المتوفرة للطاقة الكهربائية عام(١٩٨٦) ١٣٢٠ ميغاواط(٢٥٥مائي + ١٠٦٥حراري) في حين ان القدرة المطلوبة هي ٨٨٠ ميغاواط• و لكن نظرا للظروف الراهنة هناك هدر كبير في عملية استهلاك الطاقة الكهربائية في لبنان بسبب سعر الكيلو واط/ساعة المتدني و الذي لم يطرأ عليه اي تعديل منذ فترة طويلة من ناحية و بسبب عدم وجود سياسة ترشيد لاستهلاك الطاقة من ناحية اخرى• لهذا اصبح وضع انتاج الكهرباء صعبا جدا نظرا لصعوبة تأمين شراء المحروقات او لجهة صيانة المولدات الكهربائية• لذلك اجتمعت الاراء الصادرة عن الادارات و المؤسسات المعنية بوضع الطاقة على ايجاد مخارج علمية و موضوعية من هذا الوضع• فكان لا بد من اجراء الابحاث و الدراسات حول استعمال الطاقات الجديدة و المتجددة • و بحكم موقعه الجغرافي يتمتع لبنان بطاقة شمسية ممتازة، اذ تبلغ الطاقة الشمسية الساقطة •• ٦٥ ميغاجول/م^2 سنويا • و هناك بيانات تفصيلية للارصاد الجوية مع شروحات للخصائص المناخية لمختلف المناطق بالاضافة الى برامج لوجستية و خرائط تبيانية يمكن منها استنتاج كمية الطاقة الشمسية و المعطيات المناخية لهذه المناطق • هذه المعلومات تشجع على استعمال هذه الطاقة المحلية في القطاعات المنزلية و الزراعية و غيرها •

بالنسبة لاستعمال الطاقة الشمسية بالابنية يقوم مركز بحوث الطاقة الشمسية في المجلس الوطني للبحوث العلمية بأبحاث شتى حول اللواقط الشمسية المستخدمة في تسخين مياه الاستعمال المنزلي لتقييم مردودها و كفاءتها في توفير الطاقة• كما هناك ابحاث حول التصور

الحراري للبناء بلبنان بهدف ترشيد و توفير استعمال الطاقة في التدفئة و التبريد داخل المنازل بالاضافة الى وضع مواصفات لطريقة و مواد البناء• اما على صعيد استعمال الطاقة الشمسية في المجالات الزراعية هناك انتشار واسع للبيوت المحمية البلاستيكية لتحسين الانتاج الزراعي • وقد اعطت هذه التكنولوجيا نتائج جيدة و مشجعة لكن لا زال هناك مشاكل عدة تحول دون توسيع استعمالها • من بينها عدم وجود سياسة عامة للطاقة بالاضافة الى الكلفة العالية نسبيا نظرا لدعم الدولة للطاقات المتوفرة•

اما بالنسبة للتبريد هناك ابحاث تجري على طريقة جديدة تعتمد على تخزين البرودة بواسطة مواد كيماوية في الاوقات التي يكون فيها الطلب على الكهرباء خفيفا (بالليل مثلا) ليتم استعمالها في الاوقات التي يكون فيها استهلاك الكهرباء عاليا • كما سنقوم بحملة قياسات للتعرف لاداء هذه الاجهزة الجديدة في الظروف المناخية المحلية و لتقييم النتائج العملية لهذه التقنية•

١ـ مقدمة :

لم يتمكن لبنان خلال سنوات الازمة من نهج سياسة تخطيطية للطاقة بالرغم من الجهود و الدراسات التي كانت تقوم بها المؤسسات و الوزارات المختصة• فالاوضاع غير الطبيعية كانت تمنع مثلا من تنفيذ البرامج المقررة لتحسين و تطوير انتاج و توزيع الطاقة الكهربائية ،كما و أدت الى اتلاف و تعطيل بعض المنشآت القائمة • و مثالا على ذلك فان انتاج الطاقة الكهرومائية ، و هي المصدر المحلي الوحيد للطاقة ، انخفض من ١١٣٧ مليون كيلواط ساعة سنة ١٩٨١ الى ٤٦٣ مليون كيلواط ساعة سنة ١٩٨٦ (انظر الى جدول رقم ١) • مع العلم انه كان من المفترض تحسين انتاج هذه الطاقة بتجهيز محطات جديدة لاستغلال القدرات الباقية المتوفرة•

من ناحية اخرى ، هناك هدر كبير في عملية استهلاك الطاقة خاصة الكهربائية و ذلك عائد لسعر الكيلواط ساعة المتدني المدعوم من الدولة ، و لعدم وجود سياسة ترشيد لاستهلاك الطاقة • من هنا كانت ضرورة اجراء الدراسات و الابحاث لايجاد مخارج علمية و عملية تخفف من عبء استيراد المحروقات على الدولة ، و تزيد من نسبة الطاقة المحلية عن طريق استغلال الطاقات الجديدة و المتجددة كالطاقة الشمسية • خاصة عندما نعلم بأن لبنان يتلقى من الشمس ما معدله ٦٥٠٠ ميغا جول /م^{٢} سنويا •

في هذه الورقة سوف نحاول اعطاء صورة مختصرة و واضحة عن الوضع الحالي للطاقة بلبنان من ثم نتطرق الى دور الطاقات الجديدة و المتجددة عن طريق عرض مشاريع البحث التي يقوم بها مركز بحوث الطاقة الشمسية التابع للمجلس الوطني للبحوث العلمية•

٢ ـ الطاقة و مشاكلها :

في لبنان تقوم الدولة بالاشراف مباشرة على انتاج و استيراد الطاقة عن طريق الوزارات و المؤسسات المختصة • فوزارة الصناعة و النفط ـ المديرية العامة للنفط ـ تقوم بعملية استيراد المحروقات من النفط الخام لتكريره بمصفاتي طرابلس و الزهراني ، بالاضافة الى المشتقات النفطية الاخرى • هذا بالاضافة الى تحديد اسعار هذه المواد ، بحيث اعتمدت مبدأ الدعم عن طريق انشاء صندوق المحروقات • و نظرا للاعباء المادية المرتفعة الناجمة عن التضخم المالي المستمر ، تم رفع الدعم عن المشتقات النفطية مع الابقاء على تزويد مؤسسة كهرباء لبنان بالمحروقات الضرورية • اما وزارة الموارد المائية و الكهربائية فتتولى الاشراف على تسعير الطاقة الكهربائية الموضوع من قبل مؤسسة كهرباء لبنان على اسس علمية و اقتصادية بحيث يسمح بانتاج و توزيع الكهرباء بشكل سليم • و لكن رفض الدولة القبول بالزيادات المقترحة تماشيا مع التضخم المالي أدّى الى تضاعف سعر كلفة الكيلواط ساعة عن سعر المبيع مما سبب بحصول عجز مالي شل امكانيات المؤسسة و منعها من القيام بواجباتها •

ـ الطاقة الكهربائية : بدأ انتاج الطاقة الكهربائية بلبنان عام ١٩١٠ ، و هي تغطي الان معظم الاراضي اللبنانية • ان مقارنة سريعة لانتاج هذه الطاقة (جدول رقم ١) تظهر لنا تدني نسبة الطاقة الهيدرولية المحلية و التي لا تتعدى حاليا الـ ١٠ بالمئة • و لتلبية الحاجة الناتجة عن الزيادة السنوية للاستهلاك و المقدرة حاليا بين ١٠ و ١٥ بالمئة ، تقوم مؤسسة كهرباء لبنان بتركيب مولدات حرارية تبلغ قدرتها الافرادية حوالي ١٧٠ ميغاواط • اما القدرات المتوفرة من الطاقة الهيدرولية فلم يصار الى تجهيزها و صيانة ما هو مجهز منها ، مما ادى الى انخفاض نسبة الانتاج المائي من ٧٠ بالمئة سنة ١٩٧٠ الى ١٠ بالمئة سنة ١٩٨٦ (جدول رقم ١) • و كما نلاحظ بالجدول رقم ١ فان القدرة المتوفرة تفوق القدرة المطلوبة و لكن مشكلة عدم تأمين الكهرباء بشكل متواصل يعود للاسباب التالية :

ـ عدم تأمين المحروقات بشكل منتظم ، لان العجز المالي الموجود فيه مؤسسة كهرباء لبنان منعها من التصرف بحرية لاستيراد المحروقات و تنظيم عملية الانتاج و التوزيع • حاليا تقوم المديرية العامة للنفط باستيراد المحروقات مساهمة من الدولة لتخفيف الاعباء المعيشية عن المواطن •

ـ عدم التمكن من صيانة و تطوير شبكة التوزيع التي عانت من الوضع المتدهور بحيث فقدت عددا كبيرا من خطوط التوتر العالي و المتوسط بالاضافة الى بعض محطات التحويل الرئيسية و الفرعية • دون توفر الامكانات المادية و الظروف الملائمة للقيام بالاصلاحات اللازمة •

ـ تغيير في نوعية الكوادر الفنية داخل المؤسسة مما يرتد سلبا على حسن سير العمل •

هذه الاسباب دفعت المواطنين الى ايجاد حلول فردية لتأمين حاجاتهم

من الكهرباء عن طريق شراء مولدات كهربائية صغيرة تعمل على البنزين او المازوت و تتراوح قدرتها من ٥٠٠ واط للانارة مثلا داخل المنازل الى عدة مئات من الكيلواط للمجمعات الكبيرة مثل المؤسسات ، الفنادق المستشفيات و غير ذلك • فالمباني الجديدة المعدة للسكن يقوم اصحابها بتجهيزها مباشرة بمولد كهرباء ليصار الى تصنيفها بناء فخم•

ـ الطاقة الشمسية : رغم هذه المشاكل التي تعترض تأمين الطاقة على الصعيد الوطني بشكل طبيعي ، فاننا لم نر مع الاسف اي انتشار للطاقات الجديدة و المتجددة كالطاقة الشمسية • و تقتصر هذه التطبيقات على البيوت الزراعية المحمية و نظم التسخين الشمسي لمياه الاستخدام المنزلي و لكن بشكل محدود جدا • مع العلم بأن لبنان يتلقى من الشمس ٦٥٠٠ ميغاجول/م٢ سنويا ، مما يجعل هذه الطاقة من المصادر المحلية التي يجب استغلالها للتخفيف من عبء استيراد المواد النفطية • و بما ان عملية تحديد خصائص النظم الشمسية تحتاج الى معرفة المعطيات المناخية و خاصة الاشعاع الشمسي ، تم جمعها ضمن جداول بواسطة حاسب الكتروني • و لما كانت المعطيات الشمسية قليلة و غير كافية ، تم وضع طريقة حسابية لاستنتاجها و ذلك لمختلف المناطق اللبنانية •

٣ ـ استعمال اللواقط الشمسية الحرارية لتسخين مياه الاستخدام المنزلي :

تعتبر التطبيقات الحرارية للطاقة الشمسية بالقطاعين الزراعي و المنزلي الاوسع انتشارا بالمناطق المشمسة • و رغم ان لبنان يتمتع بكمية وافية من هذه الطاقة فان استعمالها يبقى محدودا خلافا لما هو الحال بالدول المجاورة • و هذا يعود الى سعر الكهرباء المتدني مما يجعلها من ارخص الطاقات المتوفرة و يدفع المواطن الى استعمالها حتى للتطبيقات الحرارية (ماء ساخن و تدفئة) بدل استعمال مصدر آخر أقل كلفة • و حسب آخر معطيات مؤسسة كهرباء لبنان فان ٦٠ بالمئة من الكهرباء مستهلكة بالقطاع المنزلي • و نعتقد بأنه من الممكن توفير نصف هذه الكمية باستعمال الطاقة الشمسية لتسخين مياه الاستخدام المنزلي • عدم الانتشار هذا ناتج عن الدعم المادي لسعر الكهرباء من قبل الدولة ، مما يجعل من غير المبرر حاليا استعمال هذه الانظمة الشمسية الى حين صدور تشريعات جديدة لتشجيع هذا المصدر الطبيعي للطاقة • و رغم هذه الاسباب فان بعض الناس يفضل استعمال نظم التسخين الشمسي للهروب من مشكلة عدم وجود المحروقات و الكهرباء بشكل دائم •

و يقوم مركز بحوث الطاقة الشمسية باجراء دراسة ميدانية على بعض النظم الموجودة و ذلك للوقوف على حسن سيرها و مقارنة مردودها مع الاستهلاك المطلوب • و على ضوء النتائج سنقوم بوضع دليل ارشادي يساعد المواطن و الاختصاصي على اختيار النظام الشمسي الافضل •

الجـــدول رقـــم (١)
مصـــادر الطـــاقة الكهربائية في لبنـــان

	القدرة المتوفـــرة (آلاف الكيلواط)					الانتـاج (مليون كيلواط ساعة)		
السـنة	* المائيـــة	* الحراريـــة	المجموع	القدرة المطلوبة	الاحتياطي	المائي	الحراري	المجمـــوع
١٩٧٠	٢٢٠	١٧٠	٣٩٠	٢٥٥	١٣٥	٨٧٧	٣٥٣	١٢٣٠
١٩٧١	٢٢٠	٢٢٥	٤٤٥	٢٩٥	١٥٠	٨٣٩	٥٣٦	١٣٧٥
١٩٧٢	٢٢٠	٢٨٠	٥٠٠	٣٢٥	١٧٥	٨٠٧	٧٤١	١٥٤٨
١٩٧٣	٢٢٠	٢٨٠	٥٠٠	٣٥٠	١٥٠	٤٧٨	١٣١٠	١٧٨٨
١٩٧٤	٢٢٠	٣٤٥	٥٦٥	٣٨٠	١٨٥	٨٢٠	١١٥٥	١٩٧٥
١٩٧٥	٢٢٠	٣٨٥	٦٠٥	٣٨٥	٢٢٠	٨٠١	١٠١٨	١٨١٩
١٩٧٦	٢٢٠	٣٨٥	٦٠٥	٣٢٠	٢٨٥	٧٠٠	٢٩٨	٩٩٨
١٩٧٧	٢٢٠	٤٠٥	٦٢٥	٣٨٠	٢٤٥	٩٥٧	٨٨٢	١٨٣٩
١٩٧٨	٢٢٠	٤٣٠	٦٥٠	٤٠٥	٢٤٥	١٠٥٧	٩٢٢	١٩٧٩
١٩٧٩	٢٢٠	٤٣٠	٦٥٠	٤٦٠	١٩٠	٤٦١	١٨٥٤	٢٣١٥
١٩٨٠	٢٢٠	٥١٠	٧٣٠	٥٣٥	١٩٥	١٠١٦	١٨٠٣	٢٨١٩
١٩٨١	٢٥٥	٦٣٠	٨٨٥	٦٠٥	٢٨٠	١١٣٧	١٩٩٢	٣١٢٩
١٩٨٢	٢٥٥	٦٣٠	٨٨٥	٦٥٠	٢٣٥	٦٤٣	٢٣٩٣	٣٠٣٦
١٩٨٣	٢٥٥	٧٠٠	٩٥٥	٧٠٠	٢٥٥	١٠٠٤	٢٣٠٦	٣٣١٠
١٩٨٤	٢٥٥	٨٤٥	١١٠٠	٧١٠	٣٩٠	٩٦٤	٢٢٩٦	٣٢٦٠
١٩٨٥	٢٥٥	٩٩٠	١٢٤٥	٧٩٠	٤٥٥	٥٧٠	٣٢١٨	٣٧٨٨
١٩٨٦	٢٥٥	١٠٦٥	١٣٢٠	٨٨٠	٤٤٠	٤٦٣	٣٨٠١	٤٢٦٤

* مجموع القدرات المجهزة في لبنـــان بما فيها القدرات المجهزة لصـــناعة الاســـمنت .

٤ ـ الحراريات و البناء لتوفير الطاقة و استعمال الطاقة الشمسية :

تهدف هذه الابحاث الى وضع مواصفات حرارية للابنية لجهة مواد و طرق البناء و معرفة استهلاك الطاقة بالمنازل للوصول الى توازن مقبول بين الراحة التي ينشدها المواطن و النفقات المترتبة عليه مما يساهم في توفير الطاقة• بالاضافة الى درس امكانية استعمال نظم التسخين الشمسي للمياه بالابنية ليصار لوضع قوانين لها لاحقا • و نقوم بهذه الدراسة بالتعاون مع مديرية التنظيم المدني المسؤولة عن تحضير و تطبيق القوانين المتعلقة بالبناء • وقد انجز حتى الان النقاط التالية :

ـ تجميع المعطيات المناخية ضمن جداول لتسهيل عملية استعمالها بالحسابات الحرارية المطلوبة •

ـ وضع طريقة حسابية نظرية للحصول على معطيات الاشعاع الشمسي بالمناطق التي لا توجد فيها قياسات •

ـ جمع المعلومات حول مصادر الطاقة بالتعاون مع مديرية النفط و مؤسسة كهرباء لبنان للوصول الى كيفية انتاجها و توزيعها و استهلاكها •

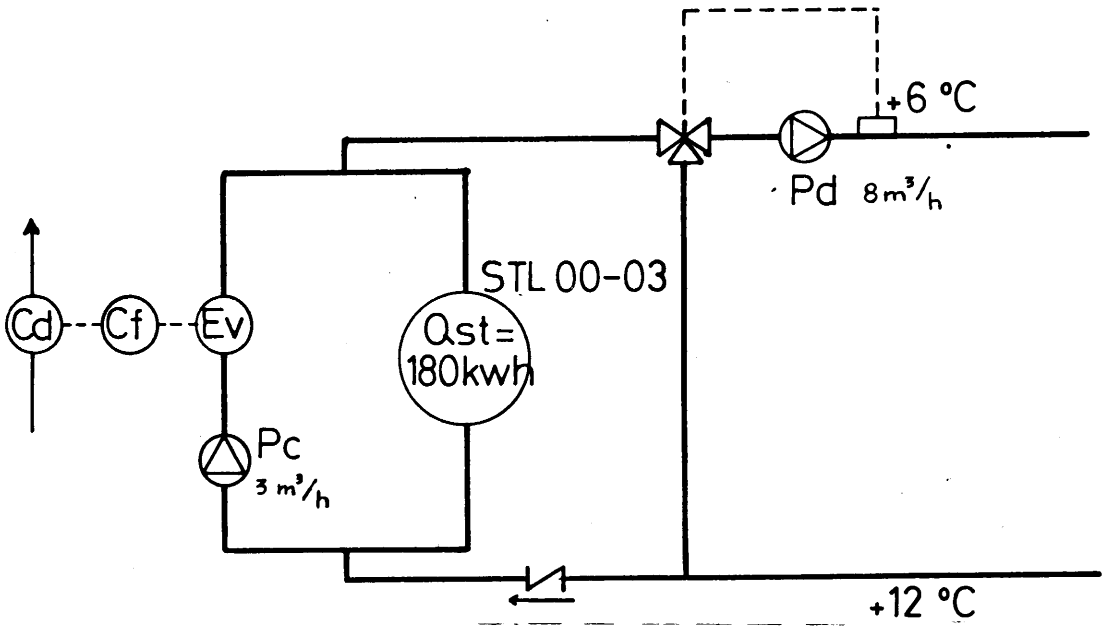
ـ الوصول لمعرفة مصروف الطاقة ضمن الاسرة عن طريق استمارات تم توزيعها في مختلف المناطق •

ـ تحديد المسكن الاكثر شيوعا بلبنان عن طريق استقصاءات أجريت على رخص البناء في مختلف المناطق •

ـ تطبيق طرق حسابات حرارية على هذا المسكن لاستخراج خصائصه الحرارية •

٥ ـ حملة قياسات تجريبية لمنشآت تكييف جديدة تستعمل مواد كيماوية لحفظ طاقة التبريد :

ضمن برنامج تعاون لبناني ـ فرنسي تم تجهيز منشآت تكييف تعتمد على تخزين طاقة التبريد داخل مواد كيماوية ذات سعة حرارية تبلغ ٤٨،٦ كيلواط ساعة بالمتر المكعب ، عن طريق الحرارة الكامنة (Latent Heat) عند انتقالها من الحالة السائلة الى الصلبة. يستعمل في هذه الطريقة خزان اضافي الى نظام التبريد العادي مملوء بكرويات بلاستيكية تحتوي على هذه المواد• هذا التخزين يتم عندما يكون الطلب على الكهرباء منخفضا (بالليل مثلا)• ليعاد استعمال طاقة التبريد المخزونة عندما يكون استهلاك الكهرباء عاليا • الفوائد المرجوة من هذه التجربة هي :



الشكل رقم ١ -

- تخفيض قدرة آلة التبريد المنوي تركيبها بالنظام العادي .
- تنظيم عملية استهلاك الطاقة الكهربائية و توزيعها على مدى الـ ٢٤ ساعة . مما يؤدي لتخفيض الطلب على الكهرباء اثناء الضغط على الشبكة .
- توفير في كلفة الطاقة المستهلكة في حال وجود تعرفة متحركة للكيلواط ساعة .

يتألف هذا النظام كما هو مبيّن بالشكل رقم ١ من جهاز التبريد الرئيسي و الذي خفضت قوته من ٥٣ كيلواط الى ١٨،٥ كيلواط و من خزان التبريد البالغ حجمه ٣ م٣ و سعته الحرارية ١٨٠ كيلواط ساعة باليوم بالاضافة الى خلاط اوتوماتيكي و مضخات و شبكة توزيع مياه التبريد.

و قد تم بالفعل تركيب هذا النظام الجديد للتكييف بالتعاون مع الوكالة الفرنسية للسيطرة على الطاقة بالمعهد العالي للدراسات الاسلامية ببيروت . و تعتبر هذه التجربة الاولى بالشرق الاوسط ، و قام مركز بحوث الطاقة الشمسية باجراء حملة قياسات و ابحاث على هذه المنشآت خلال فصل الصيف لتقييم النتائج العملية لهذه التقنية و دراسة الجداول البيانية للطاقة المستهلكة .

و قد تبين لنا من خلال هذه الفحوصات ان المواد الكيماوية داخل الكرويات البلاستيكية تتجمد على حرارة اقل من التي جاءت بالمواصفات الفنية لهذه المواد و الصادرة عن المصنع • مما يوجب تشغيل جهاز التبريد على حرارة منخفضة تؤدي الى انخفاض ملحوظ بمردوده • كما تؤثر سلبا على باقي التجهيزات الميكانيكية • و سوف نقوم بعرض هذه النتائج على المصنّع ليصار الى تغيير هذه المواد او تعديل مركباتها بحيث تتفق مع المواصفات و الخصائص المطلوبة • اما بالنسبة للمنشآت فسوف يصار الى تعديلها بشكل يسمح بالعمل على حرارة منخفضة دون الحاق الضرر بالاقسام الميكانيكية الحساسة •

PLANING FOR ALTERNATIVE SOURCES OF ENERGY IN JAMAHIRIYA

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ABSTRACT

The need for the development of alternative sources of energy in Jamahiriya is stressed.

Renewable energy resources that could be attractive for Jamahiriya are identified and the problems and prospects in their exploitation are discussed. The priorities are identified keeping in view of the social and technological background of the country. The feasibility for the development of energy resources through hydrocarbon plantations in the desert areas is outlined in particular. A planned approach involving research and development to identify suitable desert - growing plants, in particular the hydrocarbon - yielding varieties, the development of infrastructural facilities and phased implementation of the programme, is suggested. The direct and indirect benefits involved in such a programme are outlined

Before attempting to devise plans for energy resources development, it would be interesting and edúcative to look back to the past with reference to this resources. During the past centuries, man's needs for energy were very much limited but the variety of resources from which these needs were met are surprisingly large. Muscular energy from man and animals and energy from biomass, sun, wind and water currents, are examples of important sources. The advent of fossil fuel utilization marked the development of 'industrial' society leading to a shift from 'multi-resource' to 'single resource' dependence, the later being coal and then oil and gas.

The dependence of modern society on energy from fossil fuels need not be over emphasised. Technological development of any country is inter-linked with its energy consumption levels and rate at which world energy consumption levels have been increasing, especially during the later half of this century, lead to the realisation that a 'multi-resource' approach is required to meet the future energy needs of any country whether developed or developing.

The energy resource that is currently exploited in Jamahiriya is oil and gas. This resource, while meeting the energy requirements of the country, is its major revenue earner. It is estimated that 10 to 15 percent of the current levels of production is utilized to meet the energy requirements of the sparcely populated country while the rest as a revenue earner. This resource, being finite, will not last very long,necessitating planned development of other resources to meet not only the energy needs of the country but also its economic needs, replacing the petroleum revenues. Another factor that is to be taken note of is that as world petroleum resources get depleted,their economic value increases. This will accelerate the use of petroleum as a source of chemicals and other high value products instead of using it as a source of energy. Research and development effort in developing alternative sources of energy for large scale exploitation will be leading to a reduction in the cost of energy from these sources making petroleum less attractive as a source of energy.

Solar energy, photosynthesis through plantation of desert-growing hydrocarbon yielding plants, wind energy and ocean thermal energy conversion are some of the important resources that look attractice for Jamahiriya, low temperature geothermal energy below 150°C also available but its tapping for commercial use requires detailed examination of this resource. Under sea current are known to exist in Mediterranian sea but technologies are yet to be develpped for utilization of such a resource.

Before considering these sources it would be necessary to examine the social and technological background of the country. The problems faced by the country are similar to those existing in other developing countries, except that the population is very small compared to its area. Technological development is not comparable with that of the advanced countries. Technical manpower is scarce, population is mostly distributed along the coast where most of the cities and towns are located. Population in the interior is dispersed in small clusters. Infrastructural facilities for research and development are not adequate. Considering these factors, it would be desirable to choose low level and easily adoptable - technologies in the initial stages for alternative energy resource development.

At the same time few well-chosen high technology projects can also be taken up. For example, considering the long sea coast and Warm Mediterranian waters it would be worthwhile to study the feasibility of installing ocean thermal energy conversion (OTEC) plants to supply energy for desalination plants located along the coast to meet the growing needs of fresh water by industry and the populations located along the coast. Most of the present desalination plants use the flash evaporation process which is highly energy intensive, the energy being derived from petroleum sources. Adoption of membrane processes are less energy intensive for which OTEC plants can supply the necessary energy. Solar energy conversion systems with simple technologies can also be considered for applications such as drying, refrigeration and hot water systems. Installation of wind mills to serve the energy needs of remotely located population clusters and pumping water for agricultural needs looks to be another attractive proposition.

One of the most attractive resource that could be exploited using low level technologies and, relatively unskilled manpower is the photosynthesis process involving desert growing varieties of hydrocarbon-yielding plants. Considerable amount of work has been done on this topic by scientists all over the world. The work of MELVIN KELVIN, a Nobel laurate from Berkely, California, on a shrub which produces hydrocarbon substances similar to gasoline, is particularly moteworthy. The shrube, a member of euphorbia family, produces significant quantities of a milk-like sap, called latex, that is actually an emulsion of hydrocarbons in water. The main advantage of species of shrub studied by Melvin Kelvin is that it could grow well in dry regions or desert lands that are unsuitable for agriculture. Melvin Kelvin estimates that these plants are capable of producing between 10 to 50 barrels of oil per acre of land annually. The technology for production of gasoline from these plants is simple and easily adoptable by developing countries like Jamahiriya. After the plant reach the desired height, they would be cut near the ground and run through a crushing mill in much the same way as for sugarcane. From the resultant sap, hydrocarbons are separated by breaking the oil-water emulsion using the well established techniques such as use of additives for the modification of interfacial tension followed by separation by settling, filtration and centrifugation. The plants themslves regrow from their stumps. Replanting might become necessary only once in 20 years. The production costs for crude hydrocarbons are estimated to be reasonably competative to the present day oil costs. One estimate gives that these costs would be in the range of 3 to 10 dollars per barrel. Furthermore, the oil would be practically free from sulfur and other contaminants. The usefulness of cultivating hydrocarbon - yielding plants in the vast unutilized desert areas of Jamahiriya can be established if one looks at the magnitude of oil production that could be possible. Considering that about 90% of the land area in Jamahiriya is uncultivated land, we arrive at a figure of around 40×10^8 acres of desert land that could be utilized for the plantation of oil-yielding shrubs. Assuming that the annual oil production will be an average of 25 barrels per acre, the total annual production, if the entire desert area of Jamahiriya is utilized for the purpose would be around 10^{10} barrels. This would be about 15 times that of oil production in 1980. This high figure should be attractive enough for giving serious consideration to this proposal.

A systems approach is required for the implementation of the hydrocarbon yielding shrub plantations. Research and development with facilities of extension work should be the first step to establish which varieties of the plants would be best suited to the local conditions, as there are as many as 750 species of plants belonging to the euphorbia family. Studies are also required to establish parameters such as the growth period of the plants, yields obtainable, water requirements, rest resistance, residue utilization and the like, the second step would be establishment of nurseries for the supply of the plants to the plantation establishments. The project may be implemented in phases by dividing the land area into sectors and establishing national companies which can handle the work of land preparation, plantation and caretaking, water supply and collection and processing of latex for oil production. In the initial stages, only few sectors may be chosen and equipped with the necessary infrastructural facilities. After successful implementation in these sectors, the programme may be extended gradually to other sectors taking care that the expansion programme would not lead to dilution of the effort. The development of hydro-carbon plantations will not only serve the purpose of replacing finite and dwindling petroleum resource but also helps consolidate the desert land, reducing soil erosion and making it suitable for the development of agriculture during later phases. Availability of water through 'Big River' Project and the desalination plants operating on energy derived from OTEC plants or from solar energy conversion systems would then accelerate agricultural and forest development, besides meeting the growing needs of population and industry. In the distant future, greening of desert might help in weather modification, bringing more water to the land through increased rainfall. Thus, a begining made for utilization of the desert land for energy plantations, would lead to its utilization for agriculture, As development of more advanced methods for obtaining energy, for large scale exploitation from solar and sea sources might make progress in the meanwhile, emphasis for energy supply could be shifted from hydro-carbon plantations to these high technology sources making the land available for food production.

The residues from hydrocarbon plantations might be useful for producing more energy through biomass conversion or for the manufacture of paper boards, solid fuels and other useful products. In summary, hydrocarbon plantations are an attractive proposal for the supply of energy as an alternative to petroleum in near future as vast unutilized desert land is available in Jamahiriya. For growing such plants, technologies for development of these plantation are very simple and easily implementable, water requirements are very low for such plantations and lastly, once the plantations are made, very little attention would be needed to sustain the plants thereby implying very small manpower requirements.

Development of other alternative energy resources might be carried out simultaneously with priorities for wind energy in remote areas, OTEC systems as long coast is available with relatively warm Mediterranean waters. Solar energy development in its initial stages might focus its attention on low technology methods for applications such as crop drying, water heating, refrigeration and air-conditioning and the like.

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